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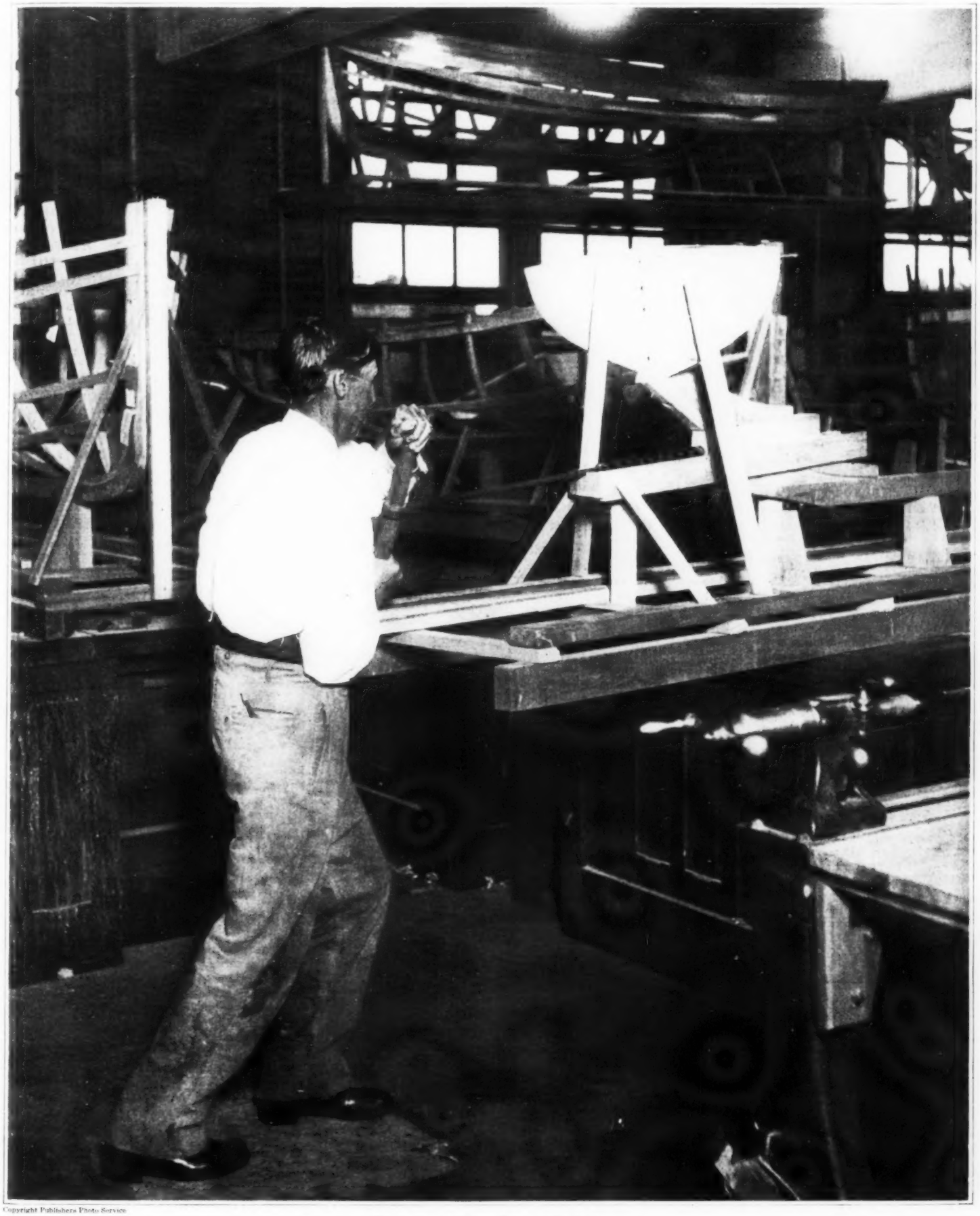

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Boring the shaft log for a motor boat

WAR SERVICE SCHOOLS AT EDUCATIONAL INSTITUTIONS (See page 196)

The Electrical Industry in America*

A Review and a Forecast

By E. W. Rice, Jr.

In the early days the progress of the electric science and arts was so rapid that it was realtively easy to find each year plenty of material for a review. Progress has continued and will continue, but naturally decided tendency to saturation is shown in many directions. In some instances, this saturation can be demonstrated to be due to the fact that limits of perfection have been so closely approached that little remains of possible accomplishment. In other instances the slowing up is due to lack of knowledge, or, especially at the present time, to lack of workers, such workers having been diverted to the work imperatively needed to secure us against the attack of our enemy on the foundations of our existence.

There has been no material improvement for several years in the matter of efficiency in electrical units such as dynamos, motors, transformers etc. The efficiencies stated in Past-President Lincoln's address in 1915, still remain almost exactly of the same values and for the reasons which he so clearly pointed out.

The efficiency of conversion of mechanical into electrical energy—or the reverse, of electrical into mechanical energy—is still about 90 per cent in the average case, under practical conditions of operation; the efficiency reaching as high as 97 per cent or 98 per cent in the most favorable cases with large units, and falling below 90 per cent in unfavorable cases, or in small units. The efficiency of conversion of electricity from high to low potential as in transformers, also remains substantially the same, reaching as high as 98 + per cent in the largest units.

It is obvious, as Lincoln pointed out, that no material change can be expected where such practical perfection has been reached.

The conversion of mechanical power of falling water into electrical energy by our water wheels and electric generators has increased from about 87 to 90 per cent in the largest units of 40,000 h.p. This represents about the limit which may be expected.

In the field of thermo-dynamic engines, represented largely by the steam turbo-generator unit, some improvement has been obtained. Lincoln stated that 75 per cent of Rankine efficiency had been obtained in some large modern steam-turbine units in 1915. This has now been increased to about 80 per cent in the largest units of 35,000 to 40,000 kw., and 75 per cent is quite common practice even in such moderate sized units as 10,000 kw. This improvement, while not large, is doubly important because of the great increase in the cost of fuel. It has been realized mainly by bringing the practical design more nearly in accord with the theoretical, by increasing the number of stages or processes of steam extraction, by reducing various losses, and by improving many details which when properly looked after make, in the aggregate, gains of practical importance.

Increasing the initial pressure of steam and lowering the terminal pressure, by better condenser arrangements, have also contributed to improvement, as they enable an increase in the range of temperature to be utilized. This makes possible better thermal efficiencies, even with the same per cent of Rankine efficiency.

The following information illustrates the improvement in efficiency of turbo-electric units beginning with the first 5,000-kw. unit installed in this country, in 1903, and continuing up to the close of 1917:

Year	Size Kw.	STEAM CONDITIONS				Per Cent. of Rankine Efficiency
		Steam Pressure, Lb.	Superheat Fahrenheit Deg.	Back Pressure, Inches	Pounds Per Kw-hr.	
1903	5,000	175	0	2	24.00	37.8
1908	14,000	200	125	1½	13.50	66.1
1911	20,000	235	100	1½	13.20	67.0
1913	20,000	200	200	1	10.74	75.9
1916	20,000	250	250	1	10.00	76.5
1917	35,000	230	200	1	10.14	78.7

It is gratifying to note that a per cent of Rankine efficiency of approximately 80 per cent has been reached. This progress reflects great credit upon the designers of turbo-electric machines and is a record of achievement found only in electrical development.

Concurrently with this improvement in the turbo-electric machines, great advances have been made in the design and operation of steam-producing devices in the boilers and in the auxiliaries and in the other features of the modern power station. As a result, the thermal efficiency has been rapidly improved. The thermal efficiency to which I refer may be stated as the ratio of the total energy produced at the terminals of the generator, to the total energy in the fuel burned—expressed as a percentage. It takes account of all losses from the coal under the boiler to the electricity at the dynamo terminals. It is the ratio of the heat units equivalent to one kw.-hr. divided by the similar heat units in the fuel consumed to produce one kw.-hr. at the generator terminals.

This thermal efficiency is after all, to the electrical engineer, the most important measure of progress. It measures the advance in station fuel economy, and, as stated, many factors in addition to the improvement in turbo-generators have contributed to the result. Thermal efficiency may obviously be used to express the results of a single unit consisting of turbine-generator, with its bank of boilers and other accessories, or it may be used to designate the combined result of all the units in a given power station.

The progress in the case of a combination unit, *i. e.*, turbo-generator, with its boilers, auxiliaries, etc., has been as follows:

Year	Size of Unit Kw.	Per Cent Thermal Efficiency
1903	5,000	10.15
1908	14,000	15
1913	20,000	18
1917-18	35,000	21.6

For comparison, I may state that large gas engines in steel mill practice, under best test conditions, show 25 per cent thermal efficiency, but in actual operation an efficiency higher than 18 to 20 per cent is rare.

High compression oil engines of the Diesel type, driving electric generators, realize 25 to 26 per cent thermal efficiency when new, but are difficult to maintain at such efficiency.

The figures given must not be confused with the much higher thermal efficiencies often quoted for gas and oil engines, which refer to indicated horse-power and not to electrical output.

The steam turbo-electric unit has not reached its limit of thermal efficiency. Calculations show that, with pressures of the order of 500 lb. gage, a thermal efficiency of 26 per cent should easily be realized. For any further substantial improvement we must look to new methods, such as the use of two fluids, for example mercury and steam, as planned by Mr. W. L. R. Emmer. This method is still under development but its progress has been hampered by the pressure of war work.

As a matter of interest to electrical engineers, I may say, parenthetically, that the steam turbine in this country owes its existence and development almost entirely to the electrical engineer; and this is not surprising as the electrical engineer was familiar with the advantages of rotary machines and, perhaps it is not too much to say, prejudiced in their favor.

While, as stated, the efficiency of electrical units reached about its limit some years ago, those familar with electrical engineering development are aware that progress has been made and is still possible in the generation, transmission, and utilization of electrical energy The struggle for improvement in efficiency has been transferred from the unit to the aggregate, called the system. We cannot have a system of maximum efficiency without units of maximum efficiency, but individual units of highest efficiency do not, of themselves, insure that the system upon which they are used will be of the highest efficiency; so progress has been made in the direction of improving the system economy or system efficiency.

To obtain the highest efficiency in practical operation, the element of time enters as a powerful factor. Our conception of efficiency should not be limited to a consideration of the relation between the instantaneous value of available heat units in coal and the electrical units produced at the point or points of consumption, but should consider the relation between the total number of heat units in fuel consumed in a given time, say 24 hours, to the total number of electrical units produced and used in the same time. The attempt to improve the efficiency of the system has shown the necessity of utilizing the generating units and transmission and distributing systems for the maximum possible time.

This has led to the study of such questions as load-factors of generators, of stations, and of the system as a whole, to the study of the diversity-factor, to the reduction of idle currents in alternating-current systems by the use of synchronous condensers, and to means for the reduction of the constant and no-load losses in all machinery, in transformers, etc.

The resulting improvement has been effected, not only by changes in designs of the units themselves, but also by their method of use, based upon recognition of the fact that the elimination or reduction of the losses at light load will greatly improve the total efficiency of the apparatus under load is a small part of the total time.

Automatic substations for transformers and rotary converters have come into existence; different power houses of the same system have been tied together electrically; transmission lines of different systems have been inter-connected, so that the units may be usefully employed for the maximum period, or lie idle or unloaded for the minimum time.

This general development has led to marked improvement in total energy efficiency, represented by the amount of fuel burned per electrical unit sold or utilized and has also reduced the cost of operation and the charges for the investment. There is still room for continued improvement in this direction and the progress will be rapid due to the pressure for maximum efficiency in the use of coal and of existing investment at the present time.

Many interesting examples of the methods and devices adopted to improve station and system economy and efficiency may be found throughout the country. In California, large electrical systems have been arranged to be tied together, electrically, for exchange of power. In Washington and Idaho, power systems under different managements have had similar arrangements. In the South, all important hydroelectric systems have been tied together for exchange of power. The advantage of such arrangements, as I have stated, is the better utilization of variable stream flow, improvement in load-factor, increased reliability of service; and the net result is to improve the efficiency of the system, not only financially, but in a purely technical sense. One most important advantage is the obvious reduction of the necessary investment in reserve machinery of every description.

In Montana, eight hydroelectric plants successively use the same stream flow, the total effective head amounting to 600 feet, and not only is the natural flow of the stream thus successively utilized, but all the storage water is effectively used by each plant in series. In this same system, the yearly load-factor is stated to reach 75 per cent and the mean monthly load-factor to reach 80 per cent.

The interconnection of hydroelectric plants brings another extremely important saving, based upon the variation of rainfall in amount and time on the different watersheds which are thereby brought to serve a common system. It frequently happens that there will be plenty of precipitation on one watershed, while another watershed may suffer from long-continued drought. This condition varies not only in the same year but in different years. Interconnection serves to eliminate these variations by a process of averaging, and where the interconnected system covers a sufficiently wide area, a remarkable increase in total useful power is made available.

It has frequently happened that thousands of horse-power have been wasted over the dams of one system, the watersheds of whose plants happened to have a wet year; and, at the same time, a nearby hydroelectric plant, supplied by another watershed, was without water power. The result has been that one system wasted power while the other was suffering from a power shortage which would frequently be made up by burning a large amount of high-grade coal in the operation of an auxiliary steam plant. This condition has to a large extent been remedied by the interconnections referred to.

It has been estimated, and it seems a conservative estimate that through the saving in reserve equipment, improvement in load-factor, and the diversity of different

*From the Presidential Address at the annual convention of A. I. E. E. Reported in the *General Electric Review*.

loads the useful output of groups of large sustems may, through interconnection, be increased about 25 per cent.

Electric regeneration of power, that is the utilization of the weight of trains running on a down grade, due to the force of gravity, to generate electricity which is fed back into the electric system to help other trains up grade, is an illustration of the same important improvement in system efficiency.

I have thought it desirable to call your attention to the improvements obtained in system economy or efficiency because of the important savings in investment, in coal, in transportation, in labor, and in material which, in the aggregate, have already been realized. It illustrates the wonderful flexibility, value and economy of a general system transmitting energy by electricity, compared with any other possilbe method.

These advances have been more rapid during the last year, due to the imperative demands for economy, saving, and increased efficiency imposed by the war. It is a great satisfaction that the foundation had all been well prepared during the times of peace.

Sixty-cycle systems have shown, during the past few years, a more rapid growth than have the 25-cycle, and it is now estimated that 60-cycle systems represent about 70 per cent of the total power supplied in the country. This is undoubtedly due to the lower cost of transformers, generators, induction motors, and similar apparatus. The relative growth of 60-cycle as compared with 25-cycle systems is reflected in steam-turbine installations. In 1910 about 60 per cent of the steam-turbine electric energy of the country was supplied from 60-cycle units; in 1917, this had risen to approximately 75 per cent.

This is an instance where standardization is desirable and economical. It will hasten the time, so often predicted, when a network of transmission lines, carrying electrical energy, will cover the country. These will be fed by super-power stations, suitably located with respect to cheap and reliable supplies of coal for fuel and water for condensing purposes, and into the same network will also be fed energy from the various hydro-electric installations.

Marked advances have been made during the past year in the application of electricity to the electric furnace. It is estimated that the number of electric furnaces in the United States has increased about forty per cent in the past year and that there are now in operation over five times the number that existed five years ago. The world's output of steel from electric furnaces has now grown to approximately four million tons per annum.

Experience has demonstrated that the electric furnace can utilize the cheapest and most inferior raw material to produce steel of the most uniform and highest quality, with the greatest regularity. The cost of steel so produced, while reasonable, considering its quality, was higher, until recently, than that produced by the open-hearth method. It is now possible to produce electric steel at substantially the cost of that produced by the open-hearth method. This result has been brought about partly by the increased cost of the open-hearth, due to a variety of well-known causes, but largely by a reduction in the cost of electric furnace operation. The marked change which has taken place in the reduction of the cost of operating electric furnaces is based upon greatly increasing the rate at which energy is delivered to the metal, both during the melting and the refining period. This has reduced the time required for an individual heat and also the kilowatt-hours required per ton of metal melted, with a net result of increasing the daily output of the furnace.

As a concrete example, I mention the history of a 5-ton furnace. It was originally supplied with 800 kv.-a. at 80 volts. This was increased to 2,000 kv.-a. at 150 volts for the melting period and about 1,400 kv.-a. at 100 volts for the refining period. The time for the heat was reduced from six to three hours, the power consumption was reduced from 877 kw.-hr. to 588 kw.-hr. per ton, and the number of heats per 24 hours was increased from three to five, thus increasing the net output from 15 to 25 tons.

Electric resistance furnaces of large sizes, for special heat treatment requiring unusual exactness, are being extensively used, producing results greatly superior to oil- or gas-fired furnaces.

Electric welding, both by the arc and incandescent method, is being rapidly extended and is destined to greater development in shipbuilding and similar operations.

Electrical engineers have been devoting much time to the solution of many war problems. It is not desirable or possible to review such work at present, but when the veil is lifted we shall all be gratified with the result. We must content ourselves with the mere statement that this work has covered means for the detection of the pirate submarine; wireless signaling and telephoning for the army and navy, and aircraft devices; searchlights of novel design and great power; improved methods in manufacture of ammunition, ordnance, etc.; electrochemical work of every description; electric welding; X-ray sets of greater simplicity and accuracy; and many other lines too numerous to even mention.

The great industrial research laboratories, and the educational and governmental research departments have all cooperated enthusiastically and effectively, and the members of their staffs have labored day and night, without regard to pecuniary reward or public applause, sustained entirely by the high purpose of giving their best to the service of the country. I hope the time may come when the story may be told so that the world may realize the debt which it owes to scientific men and engineers without whose arduous, unselfish. and almost inspired work our casue, righteous as it is, would have no chance of a victorious conclusion.

In my address at the opening of the mid-winter convention of the Institute, in February, 1918, I called attention to the advantages which it seemed to me would follow a more general electrification of the steam railroads of the country. I merely repeat at the present time that electric locomotives have been so improved and simplified that they are competent to haul the heaviest train that can be held together with the present train construction; to operate at the highest speed permissible by the alignment of the road and independent of its grades; and that the electric locomotives can meet in the most efficient and adequate manner the transportation problems confronting the country, and offer better results than are now obtained or seem possible with steam locomotives.

There can be no question that railroad electrification is not only economical but imperatively needed to improve the present standards of steam operation. Our mountain districts are congested almost entirely by the limitations of the steam railroad systems, and the addition of more tracks, under such conditions, is not the best solution of the problem. The electrified divisions of the steam roads have been free from troubles during the past severe winter, and I repeat that the coal famine which the country suffered last winter could have been largely avoided if the steam railroads had been electrified. Moreover, it should not be forgotten that steam locomotives burn about 25 per cent of the entire coal mined in the United States, and that 12 per cent of the entire ton-mileage movement of freight and passengers carried over our railroad tracks is represented in cars and tenders required to haul coal to supply steam for the locomotives.

It is a truism, which has been frequently stated, that war requires the mobilization of the nation's industries and their devotion to essential work. This is especially true in this country, as it has been necessary, in addition, to create substantially new industries on an enormous scale, such as the production of ships, ordnance, ammunition, airplanes, chemicals, etc. To operate these industries, it has been necessary to mobilize to the fullest extent our available material and labor, but material and labor can only be converted into war work by the application of power. This power, in view of its great economy and flexibility, must be electrical.

While this country was fortunate in having available a magnificent system of power stations, so great was the magnitude of the demand for increased power, created by the war industries, that it is estimated that there will be a shortage of at least 500,000 kw. of electric power in the Eastern district.

It takes from one to two years to build and equip the large units which are essential for the production of such power. This illustrates the importance of all of the methods which I have mentioned to conserve, utilize, and increase the efficiency of existing equipment and investment, as such methods can produce results in a much shorter time.

It is, however, vitally important that the great electrical power-producing companies of this country should be helped in every way to meet the heavy demand which is placed upon them. It has been demonstrated that the quickest, most efficient, and altogether best way to meet the demand for power is through the expansion of such existing organizations and installations.

Fortunately, there is general appreciation of the fact, and comprehensive schemes are under consideration which will provide for the erection of large steam-electric power stations in the mining regions. Favorable locations exist which are within reach by transmission lines of electric power stations now serving large industrial areas. By interconnection, present investment and machinery will be better utilized and a large amount of additional electric power made available, without making any increased demand upon our congested railroad facilities.

It is evident, therefore, that we need to consider and put into effect every practical method for conserving our existing developments; and, also, we should take a courageous view of the future; we should provide for the future growth at least as liberally as has been the custom of the managers of the great public-service systems in the past. It has been their custom to build from two to three years in advance of existing requirements, in anticipation of the future. I have yet to learn of a single important instance where such foresight has not been amply justified.

I would say in conclusion that the saving in fuel, by such improvements as I have mentioned in various parts of my address, amounts to many millions of tons every year; the saving in material and investment represents millions of dollars, which manifestly represent service of the highest value to the industry and to the country. Such work is just as much the province of the electrical engineer as improvements in the design and efficiency of the electrical units, and requires the same scientific ability, vision, and industry.

While I admit to considerable prejudice in favor of things electrical, I think that in no other field of engineering has there been such a remarkable improvement and a condition which so nearly approaches 100 per cent, in the matter of efficiency, as has been shown in the field of electricity. This phenomenal record is not the result of accident. It has been due to the enthusiastic devotion of the scientist and engineer and executives to their work. They have not been satisfied with things as they are, or with mediocrity. They have wanted the best, and have not been contented with a 75 to 80 per cent efficiency when something better was obtainable. The causes of inefficiency have been scientifically attacked, the losses have been studied and their causes discovered and removed.

Concurrently with the improvements in the efficiency of conversion, the engineer has studied ways and means to reduce the amount of material and the amount of labor required to produce a given effect, and has been equally successful in increasing the effective use of material and labor; and, as a result, until interrupted by the war, the cost of electrical machinery and devices of every description has shown a progressive reduction not only without sacrifice of quality but with great improvement in quality. This truly marvelous work, we can safely affirm, is the foundation of the phenomenal growth, prosperity, and present commanding position of the electrical industry, which is a monument to the broad vision, intellectual honesty, faithful work, and the correct economic viewpoint of the electrical engineer and his coworkers.

Lead Azide—A Powerful Explosive

For many years mercury fulminate has held its place as a detonating substance superior to all others. Of recent years, however, its place has been threatened by other compounds which bid fair to displace it. One of the most promising of these is lead azide, a salt of hydronitric acid. This acid forms a great number of salts, as mercury azide, silver azide, and sodium azide. The heavy azides, as lead azide are prepared by treating a solution of sodium azide, with a soluble metallic salt, such as lead acetate, the sodium azide being prepared from nitrous oxide and sodium amide. Large crystals of lead azide and mercuric azide have been found to be very sensitive to mechanical shock; the sensitiveness increasing with the size of the crystals. Even the breaking of a single large crystal is said to bring about explosion. Crystals as large as 3 mm. in length, when dry, often explode when brushed with a feather.

New Composition Opaque to X-rays

The essential feature of a radiological installation is a screen for the tube which effectively limits the field of operation of the rays. Attempts to produce such a screen have been made by incorporating with glass or ebonite certain salts opaque to the rays, but unfortunately the results obtained have not been satisfactory, as the quantity of salts used has to be strictly limited, since when beyond a certain proportion is present the composition obtained is no longer homogeneous and, in the case of certain rubbers, disintegrates with time. A composition has now been found in which the amount of salts contained is very great, and it is claimed that this new substance possesses the following properties:—It is very opaque to the rays, 9 mm. being more opaque than 2 mm. of lead; it is not brittle; it is opaque to light; it is very light compared with those in use of the same opacity; it is regular in thickness and easily workable; it is a good insulator at both high and low tensions, and it is not expensive. Photographs showing comparative experimental results are given.—*Note in Science Abstr. on a paper by Angebaud in Archives d'El. Medicale.*

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Bending light frames

Fitting in the frames

War Service Schools at Educational Institutions

MANY of our great educational institutions are devoting a very considerable portion of their resources and energies to necessary government work with most valuable results. Examples of this are the radio schools that have been conducted for nearly two years at Harvard and Columbia Universities, where hundreds of men have been trained for both aviation and sea service, and the gas engine courses given at Columbia.

When this country entered into the war, and we began to realize the inroads the submarine was making on our shipping there was a sudden demand for more small boats for the accommodation of the crews and passengers of torpedoed vessels, a demand that it was found difficult to meet because of the scarcity of boatbuilders; and following this was the necessity of providing our new ships with lifeboats, which made the situation worse. In this emergency the Pratt Institute, the noted technical school of Brooklyn, took up the matter and promptly organized classes for practical instruction in boatbuilding, utilizing for the purpose the finely equipped shops that are designed to teach a large variety of trades.

Besides instruction in boatbuilding, other classes were organized for instruction in operating and repairing gasoline engines, and in many other directions the Institute is aiding war work in practical and efficient ways.

The accompanying illustrations, taken at the Pratt Institute, show some of the different phases of boatbuilding; and it may be said that, in addition to this particular product, the students in these classes also gained knowledge that is equally applicable in the building of any size vessel. This is only one direction in which the equipment and the staff of this Institute has been helpful in war work; and today there is hardly a college in the land that is not contributing its mite in training men either in some trade or for service as officers in the army or in our rapidly growing merchant marine.

South American Frogs

By Richard Deckert

IN the amphibian collection of the Reptile House in the New York Zoological Park are several large specimens of the five fingered frogs, a species common in northern South America, where they take the place that the bullfrog occupies in the United States.

These creatures are not true frogs, belonging to the family *Cystignathidae*, which is more closely related to the toads and tree-toads. The determining characters, however, are purely internal, therefore we will speak of these animals as frogs, especially since they resemble our true frogs in appearance.

The specific name, *Leptodactylus pendactylus* means slender-fingered five-fingered, and is given this frog on account of the possession by the males of a spur on the inside of the hand, in addition to the regular four fingers. The color above is rich chocolate brown, with darker cross bands and marblings. The concealed part of the thigh is brilliant crimson, the sides of the body lemon or whitish yellow, and the throat and abdomen are pale gray with purplish marblings. A black band extends from the tip of the snout through the nostril and eye, curving over the ear-drum and ending at the insertion of the arm.

The eye is large and prominent. The lower half of the iris is black, and the upper half a beautiful pale bronze tint. The skin is smooth, moist, and when handled, very slippery, owing to a strong and acrid secretion. This secretion has a very peculiar odor, is intensely bitter to the taste, and serves perhaps, as a protection against some of the frog's enemies. On the sides of the body are several rows of large glands, some round and some oval in shape. The head is very large, and the mouth is unusually wide, even for a frog. There are no webs on the feet and the fingers and toes are long and slender for a frog of five and one-half inches head and body length.

The habits of this species are terrestrial and nocturnal. In their terrarium, they sit bunched together in the darkest corner during the day, but at night they are quite active, continuously making the rounds of their cage by means of short leaps.

Although shy creatures, they do not jump upon being touched, but at first squat close to the ground with head lowered, hissing loudly with every breath. When continually annoyed, one specimen raises itself on its limbs as high as possible, and with body slanted toward the intruder, tries to rid itself of its tormentor by butting vigorously. In this position the brilliant crimson of the inner sides of the thighs appear like fresh blood flowing from a wound.

When taken up suddenly, one of our specimens will utter a series of loud, piercing cries, like a kitten in acute pain. These cries are produced with the mouth wide open, whereas the regular calls of frogs and toads are made with the mouth closed.

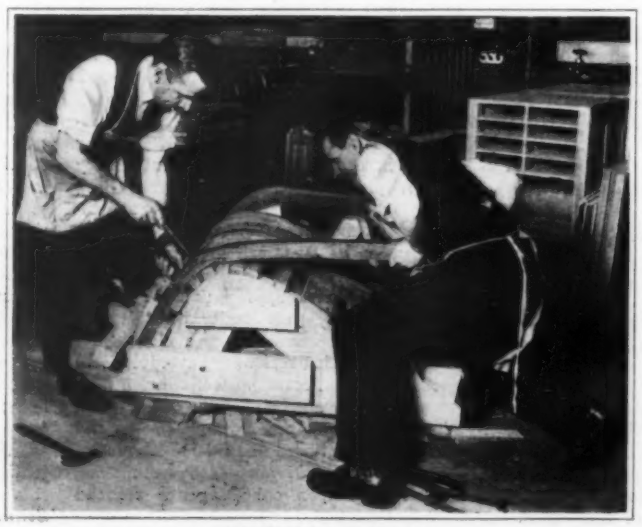
Among the many species of amphibians observed by the writer at the Reptile House, none can approach this one in quickness of movement.

When food, which consists of roaches, grasshoppers, frogs, toads, and sometimes mice, is introduced into the vivarium, the frog seems at first not to pay the slightest attention, but should the unsuspecting victim, either toad or insect, venture too near, it will be pounced upon and devoured with startling rapidity.—*Bulletin of the N. Y. Zoological Society.*

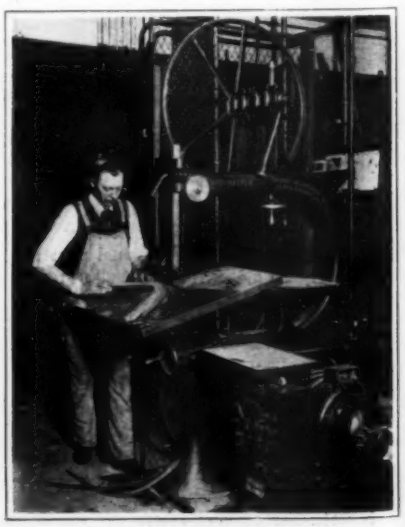
Chemical and Mechanical-technical Examination of Rubber

IN order to form a correct judgment on the quality of rubber it is necessary, in addition to making chemical analysis and vulcanization tests, to ascertain whether the various original constituents of the rubber and any substances which have been subsequently incorporated in it, remain in the same relative proportions and can be rediscovered by chemical analysis. Preliminary experiments have led to the following conclusions: The resin content remains practically constant throughout the various operations, although a slight decrease may sometimes be observed after vulcanization. The proportion of insoluble constituents is decreased by mechanical working. The protein matter is not quantitatively precipitated by the petroleum method applied for the separation of insoluble substances. When free sulphur is present to the extent of several units per cent, it cannot be oxidized quantitatively by nitric acid. The estimation of fillers by boiling with petroleum yielded with the mixture investigated (rubber 50, zinc oxide 62, magnesia 13, sulphur 5) low results, as also did the determination of the ash. The viscosity of the rubber is diminished by mechanical working on the washing rolls, and still more by working on hot rolls; this is attributed to a reduction in the molecular complexity. The indirect method for the estimation of rubber in a vulcanized product gives results which deviate several units per cent from the quantity of rubber actually used.—*Note in Journal Society of Chemical Industry on an article by J. G. Fol in Gummi-Zeit.*

Adz work



Bending heavy frames



Sawing bevels

Bending battens and lining in

Stem and stern framing

A Steel Ship Built Without Rivets

THE first steel vessel built without rivets has recently been launched in England from a shipyard operated by the inland waterways and docks section of the Royal Engineeers. This craft is a barge 120 ft. long between perpendiculars and 16 ft. beam, with a displacement of 275 tons, in the building of which no rivets were used, the whole of the structure being put together by electric welding. The efficiency of this method of ship construction has, we understand, been tested, so far as seaworthiness is concerned, the vessel, with full cargo, having been at sea during "exceptionally rough weather," and answered satisfactorily in every way to the test imposed. Great interest, therefore, centers in this departure from the ordinary system of shipbuilding, an an extension of the principle will be watched with very considerable interest. Lord Pirrie, the Controller-General of Merchant Shipbuilding, is, we understand, satisfied with the feasibility of this departure, which was carried out at a yard on the Southeast Coast, under Government control. Although in larger ships it is not proposed altogether to dispense with riveting, which in certain sections is cheaper and more expeditiously effected than welding, it is intended in some future ships to combine the two systems in the most appropriate way. The United States Shipping Board have been in close touch with experimental work, and are making arrangements for the building of a number of 10,000-ton standard ships in which the use of rivets will be reduced to about 2½ per cent of the number normally used.

The adoption of the welding process for the barge was a direct consequence of experience in welding by means of the flux-coated metal electrode process at the Admiralty Dockyards, principally in the construction of fitments, superstructures and various other parts. The component parts of the barge correspond exactly with those of a standard riveted structure with lapped joints, because the material had been ordered before it was decided to try the welding system. The hull plates, however, were arranged for clinker build and plate edges were joggled to permit horizontal downward welding, in order to reduce the amount of overhead work, which increases the difficulty of working as compared with riveting. The hull is rectangular in section amidships, with only the bilge plates curved. It was built up of 71 transverse frames with three bulkheads, those fitted fore and aft being watertight, while the transverse amidships bulkhead was non-watertight. Quarter-inch and $\frac{5}{16}$-inch plates were used for the shell plating. Though the operatives were skilled men, with extensive experience of electric welding in the shops and minor repairs and structural repairs at shipyards, progress in the first day was poor, but with experience the speed and quality of the work greatly increased. With the more difficult welding, such as the vertical butt joints on each shell-plating, and overhead work underneath the keel and on bilge plates, it was noted that the quality of the welds was excellent. For this overhead work, special electrodes were employed and proved well worth the slightly increased cost. All water-tight joints up to and including the underside of the bilge plates, were continuously welded both inside and outside, the other watertight joints being welded continuously on one side and tack welded on the other. On the shell-plating, the continuous welding was on the outside in all cases. For internal non-watertight joints and frame construction, tack welding was adopted, the length of welding being carefully calculated to give a margin of strength over a similar riveted joint. As regards the time taken, cost and quality of the work, the following information is supplied from a reliable source:

Taking all positions of work into consideration, the average speed was 4 ft. an hour at the commencement, while toward the end of the work an average of 7 ft. an hour was easily obtained. Some interesting details are provided of the comparative cost of the electric welded and riveted barge. In labor, 245 man-hours were saved in construction, which can easily be improved on in future work. More than 1,000 lbs. of metal was saved, owing to the absence of rivets, but greater economy will result when the design is modified to suit electric-welded ship construction. The total cost of welding was £301, detailed as under:

Electrodes	£178
Electric current	61
Men's time	62
	£301

It is realized by the Admiralty experts that the proportion of cost for electrodes is high, but this is mainly due to the present limited demand. Demand and competition will have the usual effect, and should reduce the cost of this item by at least 60 per cent. It will then be possible to build a vessel of this size with an estimated saving of from 25 to 40 per cent of time and about 10 per cent of material.

The new design of barge has been prepared in order that the riveting may be confined to the following: The connection of floor to frames, of beam knees to frames and beams, and the building of the frames clear of the shell seams. The following work will be done exclusively by welding: Coamings, shell seams to frames, deck butts to beams, bulkheads (including boundary bars), keel plate butts to be welded overlays, and after shell seams welded.—*Engineering*.

Sources of Platinum

THE state of affairs in Russia makes the discovery of platinum in the Serrania de Ronda, in the south of Spain, announced in a special memoir issued by the Geological Institute of Spain, specially interesting. The rocks in this region were studied because of their similarity to the platinum-bearing rocks in the Ural Mountains. The Ural deposits yielded in pre-war days about 300,000 oz. (troy) per annum—about 95 per cent of the world's yearly output. In 1916 this figure had fallen to 86,000 oz. Platinum has also been found in some quartz deposits in the Ober Rosback district of the Taunus Mountains (Germany), and these deposits are being worked. The chief source of the Entente supplies is now presumably the mines in Colombia, where the metal was first discovered in 1735. Their output is comparatively small: in 1916 it was 25,000 oz., rather more than double what it was before the war. Other possible sources of supply are the river gravels in southeast Borneo, where further prospecting is required, and various districts in North America, more especially Sudbury, Ontario, and the stream placers in Alaska, which are being investigated by the U. S. Geological Survey. Considerable activity is also reported in the Similkameen and Tulameen districts in British Columbia, which are the chief localities of platinum production in Canada. New South Wales has produced some 2,000 oz. in the course of the last five years.—*Science Progress*.

A frame ready for planking

Putting on the sheer strake

Thermostats*

Various Types and Methods of Application

By W. N. Ray, M.A., and J. Reilly, M.A., D.Sc.

CHANGE of temperature affects the values of most physical and chemical constants. In many cases the effect is a large one, as, for example, with the electrical conductivities of solutions and rates of chemical reactions. It is therefore important in such cases to carry out the determinations at a fixed temperature, and to record the temperature at which each value of the constant was obtained. A change of temperature of 0.001° C. will alter the density of most liquids by about one in the sixth place; so that if densities are to be measured with this degree of accuracy the temperature must be maintained constant to 0.001° C. throughout the determination. Constancy to this extent is the best that can be obtained at present, and is only possible at temperatures within a few degrees of the room temperature, and preferably above it. An examination of the literature of such a subject as the electrical conductivities of solutions shows that results are recorded in various cases for 15° C., 18° C., 20° C., and 25° C.; when values are given for two or three of these temperatures there is less objection to raise, but in many cases results are shown for one temperature only, and there is no agreement as to what this temperature should be. Since we are able to obtain most accurate temperature regulation when the temperature is a few degrees above the room temperature it would clearly be of great advantage to fix a standard thermostat temperature so that it would always satisfy this requirement; there are few laboratories in Europe where the temperature remains below 15° C. throughout the year, while in many tropical laboratories the average room temperature is nearer 30° C. The adoption of a uniform thermostat temperature of 25° C. in Europe and 35° C. in tropical countries with determination at both temperatures when possible would be of considerable value.

Thermostats for these temperatures consist of large baths of water or other liquid which are kept well stirred, while the temperature is regulated by gas or electrical heating controlled by some form of thermo-regulator. The advantage probably is with electrical heating as far as regulation of temperature is concerned.

It is often useful to have a rough instrument, especially in commercial laboratories. A metal capsule containing liquid, the expansion of which moves the top of the capsule and thence, either mechanically or electrically, cuts off the source of heat, furnishes one example, while a bimetallic strip which bends on heating gives another which can also be used at temperatures besides these in common use. Ostwald considers that spirals made from a band of two metals of as different expansibilities as possible rolled together might be suitable even for sensitive thermo-regulators, especially if connected with an electro-magnetic regulator.

One form of thermostat which has proved very satisfactory in practice consists of a tank of copper 60 cm. long by 40 cm. broad and 40 cm. deep and therefore holding nearly 100 litres of water. To prevent as far as possible loss of heat by radiation and so reduce the effect of variation in the external temperature, the sides are usually lagged with a layer about 3 cm. thick of some such non-conductor as slag wool.

No thermo-regulator is really satisfactory in a room whose temperature varies considerably. No lagging device will adequately compensate for external variations. If a thermostat is in an underground cellar of fairly constant temperature and free from draughts, lagging may be a positive disadvantage, as when the temperature of the bath is on the high side it takes all the longer to cool. In working fairly near the air temperature there is not much chance of the bath falling much below the required temperature, in which case only would the lagging come in useful. Also for high temperature thermostats, *e. g.*, for microscopical preparations, it is usually more important that the temperature does not exceed a certain amount, in which case lagging would be a disadvantage. Thus, while efficient lagging of the bath is often very useful it is difficult to generalize about its utility.

At the top of the two longer sides are plate-glass windows 15 cm. high and 60 cm. long to enable readings to be taken of objects completely immersed; the glass is sometimes cemented in position, but is better fixed by means of a metal frame fastened with screws to the metal tank, and with a layer of sheet rubber on each side of the edge of the glass, between the latter and the metal; such joints are water-tight, and the glass is more easily replaced when necessary.

When gas heating is used the bottom must, of course, be left unlagged; with electrical heating it can be protected in the same way as the sides. A constant level of the type used on water-baths may be employed, and should be adjusted so as to keep the level about 3 cm. from the top of the thermostat; at ordinary temperatures it is hardly necessary; it is sufficient to add some water every four or five days. A small drain-cock in one corner of the bottom is very useful for cleaning and emptying purposes. A less convenient but considerably cheaper arrangement can be made of a copper tank enclosed in a wooden case with a second wooden case, allowing a space of 2 or 3 cm. between the two; this space is filled with sawdust, cork, or other convenient insulator.

For the thermostat to be efficient, vigorous stirring is essential; good results have been obtained by using a bar passing lengthways along the bottom of the bath, and carrying six small paddles 5 cm. by 4 cm., and attached to a short arm which passes through a hole drilled in the bar and is held in position by a thumb-screw. The bar runs in vulcanite or metal bushes, which are secured to brass rods so as to be capable of vertical adjustment by means of clips fastened at the top of the bath; the height of the bar is adjusted so that the paddles just clear the bottom.

It is perhaps conducive to quieter running to have the bushes fastened to the sides of the bath near the bottom, especially since the vertical adjustment is rarely used after the initial setting. The stirrer is driven either by means of grooved pulleys and a belt or by means of toothed wheels and a chain. In either case it is advisable to use large pulleys or wheels. Twisted tape makes a satisfactory belt which will last for months. A deep groove on the pulleys prevents the belt from slipping off, while the use of large pulleys stops belt-slip under a heavy load. With toothed wheels the teeth should be cut and not pin teeth, since the latter wear out quickly. Chains of the kind used in pinanolas are used, but these stretch after a time, and then make a considerable noise as they slip on to the teeth; for this reason the use of belts is preferable in spite of the greater chance of breakage. The upper pulley is fixed by clips to the edge of the bath, and so can be moved along to take up the slack in the belt. The spindle of this pulley is connected by a spring coupling to a one-tenth horse-power motor fitted with worm reduction gear. Instead of the spring coupling, a pulley and a belt drive may be used, while the worm reduction gear may be replaced by the back wheel of a bicycle, the axle of the wheel being clamped firmly into a heavy retort stand. One belt passes from the motor round the rim of the wheel, while the other passes round that part of the hub between the chain-wheel and the spokes. The speed of the motor is regulated by means of a lamp resistance, or in the case of an alternating current by the use of a choking coil, so that the paddles make about 100 revolutions per minute. Small paddles with rapid stirring are found to be most effective.

The efficiency of various types of gas thermo-regulator has been investigated by Lowry (*Jour. Chem. Soc.*, 1905, T., 1030). He found that with a large regulator of the Ostwald type containing about 250 cc. of a 30 per cent solution of calcium chloride, the temperature of the bath showed periodic variations amounting to 0.05° C. in amplitude, and having a period of twenty minutes. Variations of the gas pressure affected the mean temperature of the bath to a large extent, but the effect is less with more sensitive regulators. A drop in the temperature of the room was found to increase the amplitude of the temperature variations.

Lowry designed two types of regulator which gave much more satisfactory results; the bulb of one was a fluted cylinder, while that of the other was a spiral. The constants of the best example of each type were as follows:—

	Fluted	Spiral
Dimensions	8 x 2 ins.	8 x 6 x 1 ins.
Volume	150 cc.	500 cc.
Movement of mercury 1 mm. for	0.017° C.	0.006° C.
Amplitude	0.010° C.	0.008° C.
Period	7 mins.	2 mins.

With both these regulators, after the initial period, the flame merely trembled and the temperature showed no marked oscillations. When gas heating is used the best results are obtained with a low and steady gas pressure; about 3 cm. of water is a convenient gas pressure to use, and this can be readily attained by the use of the gas pressure regulator described by Joseph (*Journ. Chem. Soc. Proc.*, 1914). The gas from the main enters through a thin walled rubber tube, which passes between a fixed bar and the hinged bar of a telegraph sounder. The thin rubber tube is connected by means of a T-piece to a large bottle, and to the side tube of a filter-flask which contains some 40 per cent sulphuric acid. The neck of the filter-flask is closed by a rubber stopper with two holes; through the smaller hole passes a glass tube with a platinum wire sealed at the end and containing some mercury; the platinum wire dips into the acid and so makes contact with it. The other hole carries an open tube 1 cm. in diameter, with the lower end dipping into the acid; in this tube is placed the other contact made adjustable by passing it through a large cork resting on the top of the open tube. The telegraph sounder is in series with these two mercury contacts and with a battery giving about 6 volts. When the gas pressure in the apparatus rises, the acid is forced up in the wide tube and so completes the circuit; the electro-magnet then comes into operation and pinches the rubber tube, cutting off the gas supply as long as the pressure remains high. A lead weight placed on the bar of the sounder is an advantage in reducing the amplitude of the pressure oscillations. The large bottle takes up small variations of pressure, and from here the gas passes to the thermo-regulator, a T-piece serving to connect in a water manometer which indicates the gas pressure. When the apparatus is properly adjusted the fluctuations of pressure are less than a mm., even when the gas pressure in the main is as high as 25 cm. of water.

For long runs it is very advisable to further purify the gas by washing through either silver nitrate or a mercury salt (if a bubbler is used a large "capacity" must follow) or other washing medium, otherwise the surface or the mercury in the regulator soon becomes too dirty to be really good.

Many different types of thermo-regulator have been devised. Field (*Journ. Am. Chem. Soc.*, 1914, xxxvi., 72) describes one which depends on the change in vapor pressure of ether, and which was capable of maintaining a bath of 350 liters at 30° C. with an accuracy of 0.01° C. to 0.005° C. for several days at a time. This form is not so sensitive as the toluene regulator described below, but it has the advantage of adapting itself to change of temperature of the bath with great rapidity, and therefore may prove useful when large or sudden changes in the external temperature are unavoidable. The apparatus consists of a U-tube closed at one end, having a threeway stopcock at the bend and a stopcock at the open end of the tube. Two platinum wires are fused in the open side of the tube. Dried ether and air are confined in the closed side of the tube by a column of mercury, and the increase of vapor pressure of the ether causes the mercury to make contact with the upper platinum wire, and so to shut off part of the heating circuit by means of a relay. The regulator is adjusted by the addition or removal of mercury, the air in the open arm is replaced by carbon dioxide and the tap is closed. Mercury is then poured above the tap and a rubber stopper is inserted. The three-way cock is also closed by a rubber tube and a pinchcock.

The Lowry pattern thermo-regulator is one of the most satisfactory; this, as mentioned above, is made in two forms: one a spiral closed at the upper end and connected at the lower with a narrow vertical tube rising out of the thermostat; the other consists of a series of flattened bulbs one above the other; the top bulb is sealed to a narrow tube, one end of which passes to the bottom of the lowest bulb, and the other projects above the water. The object of these particular forms is to expose as large a surface as possible, so that the liquid in the regulator will follow the small changes in the temperature of the bath with as small a lag as possible. The narrow tube which projects above the surface is expanded to about 1 cm. in diameter, and has a side tube sealed on; the top of the wide tube is closed with a rubber stopper carrying an angle tube drawn out to a fine capillary; the end of the capillary is cut off or ground square, and passes down into the narrow tube. The angle tube and the side tube of the regulator are connected by an H-tube with a glass tap in the middle which acts as a by-pass. The upper tube of the H is connected to the gas pressure regulator and the lower tube to a micro burner, such as is used in the apparatus for the electrolytic detection of arsenic. The by-pass is adjusted so that the gas which passes this way is almost sufficient to maintain the temperature of the bath at the required value; very little gas then passes

*The Chemical News.

through the regulator, with the result that the amplitude of the temperature oscillations is small and the mercury is not so readily fouled by sulphur in the gas. (If the gas contains much sulphur it should be passed through a solda-lime tube). The liquid used in the regulator should have a large coefficient of expansion and a low density and specific heat; toluene is very generally used. The regulator is filled in the following manner:—The toluene is first distilled, and is then repeatedly shaken with mercury to remove sulphur compounds, so that a clean mercury surface left in contact with the toluene will remain clean. The end of the regulator is closed with a stopper carrying a glass tube with a tap in it, and the side tube is connected by way of a tap to the water-pump. The regulator is exhausted and the tap is closed; the regulator is then inverted, the tube placed under toluene, and the tap opened so that some of the toluene enters; the tube is then again exhausted and some more toluene admitted. This operation is repeated several times until the apparatus is full; mercury is then added so as to nearly half fill the lower bulb, and the excess of toluene is removed. The regulator is then placed in the bath at the right temperature, and mercury is added or removed by a capillary tube. The final adjustment is made by replacing the rubber stopper and raising or lowering the capillary tube. A side tube is sometimes added containing a space filled with mercury into which projects a metal screw passing through a threaded hole in a round steel nut cemented on to the end of the tube; by turning the screw the position of the mercury can be very quickly adjusted so as to give the required temperature; the arrangement does not commend itself for very accurate work, and is likely to lead to small chance variations of adjustment which might not be noticed until too late. Two thermometers are required, one a sub-standard reading from—10° to 50° C., each degree being sub-divided into tenths, so that temperatures can be obtained accurately to 1/100° C. and estimated by means of a microscope to 1/500° C., and a Beckmann thermometer. The two thermometers are fixed in the bath so that the points on the scales corresponding to the required temperature of the bath are as near to the surface of the water as is consistent with convenience of reading. The temperature of the bath is then adjusted to that required as indicated by the sub-standard thermometer, the readings being made with the aid of a small microscope and the necessary corrections being applied. The temperature on the Beckmann thermometer is then read, and in future the bath is always adjusted to correspond to a fixed point on the Beckmann thermometer; the latter adjustment can always be made correct to 0.001° C., although the actual value of the temperature is not known to the same degree of accuracy. In general, it is more important to get a steady temperature than to aim at any definite reading.

Whitaker's modification of thermo-regulators for gas consists in cutting off the gas by the mercury just at the top of a capillary tube, which rises from the bulb. A little well is ground at the top of the capillary, the angles of the bottom being as low (*i. e.*, as nearly horizontal) as is compatible with ensuring that the mercury will trickle back every time. The cut-off tube must approach very near indeed to the bottom of the well (say one-sixteenth up). The end of this is ground off internally at an angle estimated to be approximately tangential to the mercury globule where it touches it, thus disturbing and deforming it as little as possible. Ostwald lays great importance on the shape of the end of the inlet pipe. He considers it better to cut off the tube at right angles to the axis, so that it is shut off by a very small rise of the mercury and opened again by a corresponding small fall. Mane and Marquis have devised a simple and easily regulated thermostat (*Comptes Rendus*, 1903, cxxxvi., 614). Their instrument maintains a constant temperature to within two or three hundredths of a degree. It is composed of a cylindrical enamelled iron vessel of 15 litres capacity filled with distilled water. The vessel is placed inside a vessel of slightly larger dimensions, and the space between is filled with sawdust. The bath is heated electrically by means of a platinum wire, and the current regulated with the aid of a rheostat. The agitator is worked by a small electric motor. The constant temperature is maintained by means of a thermo-regulator consisting of a large glass cylinder filled with acetone or other liquid. The liquid selected should have a sufficiently large coefficient of expansion to give the apparatus a suitable sensitiveness. The expansion of the liquid causes the level of a mercury column to vary in the proximity of a platinum point. The current necessary to establish an electric circuit for the make and break is furnished by an auxiliary pile. It acts as a relay which connects the heating current.

For electrical heating the apparatus can be arranged conveniently thus: The bath, stirring gear, and thermometers remain as before; as heaters two hot-point immersion heaters are used capable of taking 2 or 3 amperes at 100 volts; one of these replaces the by-pass in the gas-heated arrangement, the other is operated by the thermo-regulator. The former is connected to the mains with a choking coil or lamps in series to regulate the current, so that by itself this heater will keep the temperature just below the required value; instead of the heaters, carbon filament lamps may be used. The Lowry thermo-regulator has a thick platinum wire sealed into the bottom, making contact with the mercury inside. The other contact is a platinum wire mounted on a thin brass rod on which a screw thread is cut, and with a head having a milled edge at the top; the screw moves through a nut cemented into the top of the regulator and provides an easy method of adjustment. The side tube of the regulator is closed with cotton-wool. The regulator is in series with two storage cells, a 2,000 ohm sliding rheostat, and a Post Office standard relay; a current of a few milli-amperes is sufficient to work the relays, but to prevent sparking with consequent injury to the contacts a condenser of 0.5 microfarads is connected in parallel with the relay terminals; the condenser may be replaced by a pair of aluminum plates insulated by glass tubing and held together by two rubber bands; the plates are about 8 cm. by 10 cm., and are immersed in a beaker of distilled water (Browning and Symons, *Trans. Faraday Soc.*, 1915, xi., 60). The second heater is connected in series with the mains, a lamp resistance, and the relay, the contacts being again shunted with a condenser. When the temperature rises contact is made in the regulator; the current from the storage cells then operates the relay, breaking the contact in the heating circuit; when the temperature falls, the current in the relay ceases, the spring in the relay then pulls the arm back, and again makes the heating current.

Either of the above thermostats will keep the temperature steady to 0.001° C. for weeks, while for longer periods they can be relied upon to 0.002° C. For some purposes it is necessary to use a thermostat adjusted to some temperature between zero and the room temperature; the heating arrangements of the ordinary thermostat can then be replaced by a coil of thin walled copper tubing carried round the walls of the thermostat near the top; ice water is passed through the coil, and the temperature is controlled by a thermo-regulator working a relay which cuts off the supply of ice water by pinching a thin walled rubber tube (Browning and Symons, *Journ. Soc. Chem. Ind.*, 1914, 33), somewhat in the same manner as in the gas pressure regulator described above. The top of the thermostat may be covered with plate-glass cut in three strips for convenience in removing. Greater accuracy than 0.01° C. cannot be obtained at these temperatures. Morgan (*Journ. Am. Chem. Soc.*, 1911, xxxiii., 334) devised an arrangement for maintaining a small thermostat at any desired temperature between 0.1° C. and 90° C. to a few hundredths of a degree. The regulator has a U-shape, one arm of the U being 3 cm. in diameter and 15 cm. long, and closed by a tap with a funnel above it. A platinum wire is sealed in this side, and bends vertically down so as to reach a point about 1 cm. above that at which the tube narrows. The bend of the U-tube is a capillary of 0.75 mm. diameter; about 6 cm. above the bend this expands to a diameter of 4 mm., which continues to the top of the tube; to the end of the tube is fixed by means of a thumbscrew a threaded collar with a binding screw. A threaded brass rod 2 mm. in diameter passes through the collar and terminates in a short stout platinum wire. Mercury is added to within 3 cm. of the top of the capillary, and then purified toluene is poured in to fill the larger side tube. The stopcock is left open while the temperature of the bath is roughly adjusted to the required value, and is then closed, the final adjustment being made by means of the threaded brass rod. The two wires from the regulator are connected to a 2-volt cell and a relay which will operate so as either to make or break the current in the main circuit. The connection in a P. O. standard relay can be made so as to produce either result. The main circuit may consist of D. C. current from the mains passing through a 32 C. P. lamp, and an electro magnet arranged like the telegraph sounder, except that the brass bar is prolonged and has a weight of several kilograms, attached to it, so that when no current passes the weight causes the other end of the bar to press upward against a metal stop. Between the latter and the bar passes a thin walled rubber tube which is compressed so that no water can flow through it. The bath has an overflow so as to keep the water-level constant, and ice water or hot water from a reservoir giving a pressure head of 40 to 50 cm. passes into the bath through the rubber tube. At temperatures below that of the room the electric circuit is arranged so as to cut off the current and allow ice water to flow when the expansion in the regulator makes the current there. For higher temperatures the connections are arranged so as to break the main current, and cut off the hot water supply when the temperature causes the regulator to make the current in the relay. Thermostats to give exactly 0° C. are rather difficult to arrange. Since water just above 0° C. is less dense than that at 0° C. it is advisable to have a good supply of ice at the bottom of the tank. A false bottom of perforated zinc is therefore fitted 15 to 20 cm. above the bottom of the bath, and on this rests a rectangular perforated zinc box of such a size as to leave ample space for ice between it and the side of the bath; the box forms the actual working space, and can be fitted with a stirrer, etc. When preparing the thermostat for use crushed and washed ice is packed on the bottom to a height of 15 to 20 cm.; the false bottom is then secured in position, and on this the rectangular box; the space between the walls and the box is then packed with lumps of ice up to the top; ice water is next run in to the desired level, and finely crushed ice is put in to a depth of 2 or 3 cm. in the top of the box and a plate-glass cover placed on the whole.

For high temperature an electric furnace is described by Waidner and Burgess (*Bull. Bur. Stand.*, vi., No. 2). It consists of a resistance furnace mounted vertically, and having two separate heating coils of platinum ribbon 0.01 mm. by 2 cm. wound on porcelain tubes with the turns so spaced as to allow the establishment of a uniform temperature over a considerable length of the furnace. A separate rheostat controls the current in each circuit. Temperatures are read by means of a platinum resistance thermometer, and it is possible, by adjusting the rheostats by hand, to maintain the temperature steady to a few hundredths of a degree.

Recent Observations on the Solar Coronas

THE simple examination of the sky during the daytime nearly always exhibits the sun surrounded by a circular whitish luminescence whose diameter and whose intensity are susceptible of great variation. Leaving aside all theoretic considerations with regard to this apparition, a Zurich astronomer, M. Maurer, recently published in the *Archives des Sciences Physiques et naturelles* an account of the systematic investigation of this subject made by him since the profound atmospheric disturbance of 1912.

The exhaustive and continuous study of the solar nimbus shows that it often constitutes a veritable corona, and that it presents the simplest and most certain criterion of the purity of our atmosphere.

The first result of the observations begun by M. Maurer in 1912–13, is that the great solar nimbus attains a minimum diameter twice a year, in April-May and in August-September; at these periods it may even entirely disappear.

But the year 1916 took a very different course from spring to fall. The spring minimum was but slightly marked, and even in April the Corona had attained a diameter of 100°. Then in July and in August of the same year the nimbus had assumed, even in a blue sky, enormous dimensions approximately 140° in the middle and at the end of August; this was the mark of an optical disturbance of the atmosphere which had been revealed by other signs so early as the beginning of April.

The solar nimbus exhibit svery remarkable phases at the periods of great solar activity; with diameters of 70°–80° and even of 100°, it is surrounded with a border of a distinct color of a tint shading from red to yellowish brown. It then gives the absolute impression of a circle of Bishop, but of markedly greater diameter. The intense apparitions of this border are accompained without exception by notable telluric and atmospheric phenomena (polar auroras, telluric currents). It is most probable that these phenomena are to be attributed to extensive emissions by the sun of cathodic rays, conformably to the views of Birkeland. The rapid appearances and disappearances of the colored ring are incompatible with the idea of an intermittent aureolo due to clouds of volcanic ashes. The explanation of the solar nimbus by the theory of diffraction presupposes the presence of particles which are extremely tenuous and very close together. These particles might be engendered by the nucleii of condensation sent to the earth by the sun in its paroxysms, and which would also exert the polar auroras.

The observations made at Davos by M. Dorno seem to reveal the existence of an intimate and regular relation between solar activity and the appearance or accentuation of the great solar corona. We have here a correlation which requires to be verified by prolonged observations made in very diverse localities and at elevated altitudes.

A plate engraver at work

The transfer press

Ruling straight lines on the plates

Making and Destroying Paper Money

How the Bureau of Engraving and Printing and the Redemption Division Work

By C. H. Claudy

In the new Bureau of Engraving and Printing at Washington the United States government possesses the largest and finest plant in the world for making engraved money. No other country takes as much pains with its currency, bonds, postage stamps and engraved government paper, and no private concern produces handsomer or more carefully printed examples of steel and copper plate work than does this Bureau of the United States Treasury. No effort or expense is spared to make United States paper represent the highest pinnacle in the art of steel engraving.

Four classes of engravers work on United States currency. They are called portrait, square letter, ornamental and script engravers, and each does only the work of his own class. Spending their lives in doing only one kind of work they become abnormally expert in that particular line and, even should they so desire, have the less ability to leave the government and prepare counterfeit plates.

In making a "bill" the first step is the preparation of the design. When this has been approved, the engravers go to work upon it, each doing his particular share of the "bill" upon a separate piece of the finest of soft steel. One man will make the portrait, another the ornamental work, another the letters, etc., until all such labor has been completed. When proofs of this collection of work have been approved the originals are hardened by a secret process and are then turned over to a "transferrer" who makes of each a steel roller, in which the negative engraving appears as a positive relief. These rollers in turn are hardened and from them a plate maker makes impressions upon a flat soft steel plate. When the plate maker has finished with his many different little steel rolls, he has a flat steel die-plate on which appears *all* the engraving of *one* side of any particular note. From it rolls called die rolls are made.

Hardening the plate in molten potassium cyanide

The die rolls, of course, contain *all* the engraving for one side of a note. After the die roll is hardened, it can be used repeatedly to make as many printing plates as may be desired.

This may seem a somewhat complicated process, yet except by making many rolls from steel engravings, from all of the rolls a single die plate, from the die plate a single die roll, and from the die roll many printing plates, the modern process of making engraved money in quantity would not be possible. There are not enough steel engravers in the world to make plates by hand alone, fast enough to keep up with the wearing-out process of Uncle Sam's money.

After the printing plates are engraved by rolling with the die roll under the proper amount of pressure they must be hardened to stand the wear of printing. The hardening is done in a rather odorous room in which are furnaces of an odd pattern. In the furnaces is a molten mass of cyanide of potassium, sufficient being used in one furnace to poison two million men. The soft printing plate is dipped in this molten mass, where it remains for twenty-five minutes. When it is removed it is of the exact redness required to produces the proper hardening. Hardening is accomplished by plunging the glowing plate into an oil bath where it remains for but a short time, after which it is dropped sizzling, into cold water. The depth of the hardening thus accomplished is slightly less than one-hundredth of an inch but it takes a long time to wear it off.

After hardening and cleaning, the plate containing four impressions of the back or face of a note, is ready for the plate printer. At present half the work of printing "bills" in the Bureau may be legally done by power presses. This is in accord with what is known as the Compromise Law, by which the United

Sizing the soft sheets to make them fresh and crisp

Printing the seal and serial number. The sheets are now real money

States Government agreed, after a long and bitter fight waged by the plate printers, that the more important or portrait side of a bill should be printed by hand and the back printed by power presses. At the present time more hand than power press work is being done at the Bureau.

The plate printer performs what apparently is a very simple act. He puts the ink upon the plate with a roller, rubs it off with a cloth and finally with his hands, his assistant places a sheet of dampened paper upon the inked plates, which now apparently contains no ink, and the printer revolves the handles of his press. The assistant takes from the other side the sheet of paper which now bears the impress of one side of four bills. This process, simple as it appears, however, is difficult to do well. The printers must know the exact amount of ink which must be used, the exact amount which his wiping hands must permit to remain in the engraving of the plate and just how the paper is to be adjusted to the steel, a matter of experience.

It is necessary that the paper be dampened before it goes through the press and as it is dried after it comes from the press it must be again dampened before it goes through the press the second time. The paper when it is finally printed on both sides, thus no longer presents its original condition of fresh crispness. Therefore when finished the four "bills" are run through a sizing bath. When again dried, the sheet is subject to a pressure of between twenty-five and thirty tons between smooth mill boards in a hydraulic press.

To the casual eye such a sheet needs only to be cut in four pieces to produce four United States "bills" of a given denomination. The expert, however, will tell you that this printed matter is not yet money and no bank would accept it as such. These sheets have not yet the seal of the United States, their denomination in another color than the face of the note or the serial number. Until the paper receives these additions, it is nothing more than a handsome example of the steel engraver's art, and has no value whatever as currency.

The machine which turns this printed matter into money is a wonderful example of automatic mechanism. Essentially it is nothing more than a rotary press, with the type which impresses the serial numbers upon the bills changing with each revolution. A girl feeds sheets of four bills each unto one end, another girl takes them out at the other and examines the piles which she removes to see that the beginning and ending serial numbers check up. The piles of bills are next passed to counters seated at long tables. A man attendant controls the speed of the press and grades it according to the skill of the girl who is doing the feeding Should the girl who is feeding make a mistake and fail to slip a sheet into the machine at the right time, she instantly pushes a small lever which stops the press. Otherwise the serial number would print upon the platen instead of on the bill and it would be necessary to reset the numbers. Moreover, the sheet of paper on the platen which took this impression would have to be cut off and carefully saved to prove to those in authority that the mistake had been made as stated.

Printing one side of our paper money on power presses

Receiving old bills for exchange

Punching holes in packages of bills to be destroyed

For there are no mistakes made in the Bureau of Engraving and Printing which are not accounted for. This is a literal fact. Nothing is ever lost. No sheet of paper comes into the Bureau but what a sheet of paper or an account of a missing sheet goes out at the other end. No waste paper is burned except in the presence of witnesses who know exactly where that waste paper came from and why it is being destroyed. At any moment of any day those in authority can tell you exactly how many sheets of paper there are in any room in the Bureau. There is no possibility of one employee shifting the blame for a mistake to another. Every sheet of paper which passes from hand to hand and from room to room is counted before and after each passage. Sheets will be counted as many as fifty times a month in going through the Bureau. Sheets of bills are counted, separate bills are counted, paper is counted as it comes in, counted as it is wet, counted as it is dried; it is count, count, count, all the time.

The result is that it is impossible for anything to get lost—and nothing ever does get lost. Once, many years ago, a sheet of paper did get mislaid in some way. No one knows to this day whether it was stolen, whether it fell into the sizing bath and was never taken out or whether it stuck to a dampening cloth and went to a laundry. It is the single instance of its kind. The employees of the room in which it disappeared paid, not for the price of the sheet of paper, but the face value of the money which would have been made out of that sheet of paper had it been allowed to take its proper course.

In former years when an error of any sort, a smudge or a tear, marred a sheet of four bills, all four were destroyed. Now,

Cutting the bills in two—another stage in the process of destruction

Checking off bundles of old bills and dropping them into the macerator

Millions of dollars of face value are reduced to pulp in the macerator daily

only the one affected is destroyed and the three others in that sheet of four are saved. They are marked with a star, which appears in front of the serial number, and inserted in place of bills which may be marred as they come through the numbering and counting machine. When a banker receives a package of money from the United States Treasury he may find on the band which holds it together the statement "Serial numbers in this package are not consecutive, bill No. so-and-so being replaced by bill No. so-and-so." The replaced bills which are not consecutively numbered will always have a star before the serial number.

No one can say that he knows the operation of the Bureau of Engraving and Printing simply by watching the manufacture of paper money, whether it be green backs or yellow backs. So much else is done in this great manufacturing plant that it is hardly fair to call it only a "money-making institution." Bonds of the United States are printed here, postage stamps, revenue stamps, and in fact all the fine printing of the United States government. More than three and a half million dollars annually are appropriated by Congress for the operation of the Bureau of Engraving and Printing. According to the last official report the year's work consisted of 307,000,634 sheets, of which more than 71,000,000 were United States notes and certificates, 18,300 United States bonds, 19,134,000 sheets of national bank notes, 16,000,890 sheets of Federal Reserve notes, 88,000,000 sheets of internal revenue stamps, 260,000 sheets of custom stamps, 108,000,000 sheets of United States postage stamps, 63,000 sheets of parcel post stamps, 266,000 sheets of Philippine postage stamps, 361,000 sheets of silver certificates and 2,500,000 sheets of checks and drafts. In addition to these, miscellaneous work was executed to the value of over $130,000. If the face value of all the classes of securities were calculated the total amount turned out in one year would be $3,558,150,626.31.

It is usually easier to destroy a thing than to make it, but when it becomes necessary legally to destroy wornout United States currency, the operation is by no means as simple as might be supposed.

"Bills" wear out in service. Every bank in the United States is constantly forwarding old and used up currency to the Redemption Division at the Treasury in Washington, and receiving new money in exchange. Formerly, only new money was issued, but the invention of the laundering machine has changed the practice. Bills which are not torn or mutilated and which are suffering from creasing and dirt more than from actual disintegration are washed, resized and ironed in a laundering machine and come out at the end of the process in such a condition that only an expert, or a comparison of serial numbers with recent bills, can prove them to be old.

But many of the bills sent in for redemption are hopeless—to launder them would be a waste of time and money. Particularly is this true of the "small change" of commercial life—one, two and five dollar bills, which of course wear out much faster than ten, twenty, fifty and hundred-dollar bills. The wornout bills, no longer fit for service, are destroyed, and their places taken by new money.

But this destruction is a matter of extreme care on the part of Treasury officials. A "bill" once destroyed, is destroyed forever—there can be no going back and recounting it, or checking up a possible error. If there was space enough in the Treasury, destroyed bills might be cut in half and only half destroyed the rest being preserved for record—but there isn't space. So the destruction is accomplished with every possible safeguard, to prevent anything being destroyed that should be kept, or anything kept that should be destroyed.

The means of final destruction is simple enough—a mechanical maceration in the presence of acid and water, turns the already soft and worn bills into a pulpy mass, which is sold at a nominal price, usually to those who wish it for the purpose of making souvenirs of Washington for the interested visitor. Little Washington Monuments, minute Capitol Buildings, and tiny White Houses made in a mould of this pulp—a greyish *papier mache*—are familiar sights on all souvenir stands. They are usually embellished with a printed statement to the effect that they contain the destroyed pieces of bills aggregating so many millions of dollars—a pleasant and pleasing fiction which hurts no one. Moreover, no one can deny the statement, because no one knows just how much money may be represented in any such souvenir!

Before condemned currency is destroyed it is counted—and counted—and counted! There is no guesswork as to the bills which go to the Destruction Committee, as it is called. This committee, which actually handles the money in the process of destruction is composed of representatives from the office of the Secretary of the Treasury, and from the fiscal bureaus concerned. Inasmuch as nearly four hundred million notes in a year, with an average nominal (face) value of more than one billion, five hundred million dollars, pass through the macerating machine, it can be easily seen how important it is that this necessary destruction be safeguarded in every way.

The destruction is effected by first cutting the packages into pieces with a great iron knife in a special cutting machine, or in some cases, in punching it full of holes with a punching machine. This work at once makes the bills valueless, and prevents any possible dishonesty or stealing of an old bill during the process of handling. Next, the cut or punched bundles of what once was money, but which ceased to have that identity are fed into the open maw of the macerating machine, which is in the room below, with its contents quite inaccessible. Here acids eat up the ink and make the paper into pulp, helped by rotation and the macerating fingers of the engine. When the destruction is complete, what remains is nothing but a thick syrupy *papier mache*, which has no more resemblance to our familiar green or yellow backs than to so much cheese.

A new five-dollar bill may go into some miser's stocking or some one's safe deposit vault and come out at the end of 50 years as good as new. But the *average* five-dollar bill will stay in circulation not quite two years and nine months, while the *average* one-dollar bill will stay in circulation slightly over three years. It seems odd that the one should last longer than the five, but the explanation is simple. Five-dollar bills are more often handled alone than one-dollar bills—for instance when a five-dollar bill is tendered for a small purchase, four ones are returned with small change. The inner two of the four ones are not subjected to the same wear in a pocketbook or handling, as are the outside two. Hence, one-dollar bills last six months longer than fives.

War Coins of the Central Powers

THE outbreak of the war restricted the Central Powers, Bulgaria and Turkey to their own resources as to the supply of coin metals and their possible substitutes. Turkey and Bulgaria possess rich mines, but they are not much exploited. The gold and silver mines of Hungary and Transsylvania are locally not unimportant, but insignificant, of course, by comparison with those of the British Empire and America. Austria and Germany extract a quite insignificant amount of gold and a little more silver as by-products from other ores. As regards nickel, the whole world practically depends on Canada and New Caledonia. When gold was withdrawn from circulation, the demand for silver coins naturally increased, and the tendency of hoarding money in coin, and not in notes, developed strongly. The German silver coins are still of the same fineness as before the war; to make the silver less attractive, however, the final etching is dispensed with, so that the coins do not look so bright, but dull black-gray. Nickel served in Germany before the war only as material for the equivalents of the half-penny, penny and multiples of the penny; the 25 pfenning-piece was made of pure nickel, the smaller coins of 75 per cent of copper with 25 per cent of alloy. Austria also coined florins of the alloy; Turkey introduced small nickel coins in 1911, when adopting the gold standard; Bulgaria also had nickel coins. In Germany, the nickel is now replaced by iron; the half-penny (5 pfennig) weighs 2.5 grams, just as much as the former nickel coin—they were used for checking the weight of letters—and has a diameter of 17.5 mm.; 400 pieces (aggregate value, 20 marks) are coined from 1 kg. of iron; the 10-pfennig piece has a diameter of 21.3 mm. The material is a tough, very low carbon Siemens Martin steel, of 33.6 per cent elongation; the mechanical properties have to satisfy certain conditions, but there are no particular specifications as to silicon, phosphorus, etc. To reduce rusting, these pieces are coated with zinc, generally by the Sherard Cowper-Cowles process, after being coined; the practice varies, however, in the six German mints, we see from a communication by Trenkner, of the Berlin mint, in *Metall und Erz*, of March 8, 1918 (pages 68 to 73). The Schoop metal-spraying process was also tried, but it remains in use only for preparing tokens of metal-sprayed paper, which serve as money substitutes in large establishments, camps, etc. Extensive experiments have been conducted on the corrodibility of the sherardized iron coins. They turn yellow-brown in distilled water in 24 hours, but rust much less in ordinary supply-water; the specks of rust, forming mainly along lines in the direction in which the iron was rolled in the mills, can easily be wiped off, even after five days' immersion in the water; bad cases of rusting have occurred, however. In sulphuretted hydrogen the iron turns black, then gray. Soap, ammonia and salt also favor rusting. The observations on the effects of high temperature are interesting; at glow temperature the zinc escapes from the surface layer of $FeZn_7$, with almost explosive energy, but the die-pattern remains distinct. These high-temperature experiments were made because the money is sometimes kept in the old-fashioned German tile-stoves. The coinage of copper was discontinued in 1917. Aluminum had been coined to a small extent before the war; the smallest coins, 1 and 2 pfennig pieces are now made of aluminum, which is more attacked by ordinary water, soda, salts, etc., than by distilled water. Zinc coins have recently been introduced. Zinc coins had been used in French Indo-China; they are again more apt to corrode, especially when impure with lead, cadmium, and iron, in distilled water than in ordinary water; they turn yellow-brown, but assume a pleasant gray tint in soda and salt. On the whole, the cheapest iron coins have answered best.—*Engineering*

A Serious Wheat Disease Discovered in the East

THE Department of Agriculture calls attention to the fact that a serious disease of wheat, long known in Europe, has recently been found in certain parts of the United States, particularly Virginia, according to the United States Department of Agriculture. In some Virginia fields losses have been as high as 40 per cent of the crop. The department urges growers to be on the lookout for its appearance and put into practice measures that will prevent it from spreading. Such measures are described in a circular just issued by the department.

The disease, caused by a small nematode or eelworm, usually affects the wheat heads, although it may occur on all parts of the plant above ground. Affected heads stay green and ripen late and are smaller than those not affected. The shaft usually opens at a wide angle. In place of grains of wheat the affected heads contain dark, hard galls somewhat shorter and thicker than wheat grains. Control measures consist of planting only disease-free seed, practicing crop rotations, and preventing the spread of the nematodes from one field to another by means of infected soil which may cling to the feet of men or animals or to farm implements.

The disease was first reported to occur to a slight extent in 1909 in California, New York, West Virginia and Georgia. After that nothing was known of the trouble until 1917, when it was located in one place in Virginia. Since then it has been found in many points in the same State and in one locality in California. Recent examinations of this year's crop shows as much as 40 per cent loss in certain fields in Virginia. Quite likely the trouble occurs even to a considerable extent in other States, and has been merely overlooked or mistaken for bunt, cockle seed, or bin-burnt wheat.

In addition to preventing the spread of this disease the Department of Agriculture urges that steps be taken to stamp it out in localities already infected, and to stop its further introduction from foreign countries. Plant only clean, sound seed from fields in which the disease does not occur. If this can not be done the galls may be separated from the wheat kernels by pouring the seed slowly into a pail of water and at the same time stirring vigorously. The galls will rise to the surface and can be skinned off. However, if left in the water more than 10 or 15 minutes, they may become water-soaked and sink. Galls may also be separated from sound grain by putting the seed in water which has been heated to 54 or 56 degrees C. for 10 to 12 minutes, a treatment which is also effective against smut.

Fields in which the disease has appeared should not be planted in wheat for 2 or 3 years. Any crop may be used in the rotation, since only wheat is known to be seriously attacked.

Sanitation is also recommended as a means of preventing the spread of the disease. Soil from infected fields should not be carried to uninfected areas either by the flow of surface water or by clinging to the feet of man, or animals, or to farm implements. A deep plowing under of stubble just after harvest lessens the spread of the disease either to nearby fields or within the same field.

Liquid Ostrich Eggs

THE report of the Imperial Institute on a consignment of ostrich eggs in liquid form gives the following analytical data: Water, 75.1 per cent; protein, 10.7 per cent; fat, 11.4 per cent; and ash, 1.4 per cent. Chinese liquid eggs contain: Water, 70.7 per cent; protein, 12.7 per cent; fat, 12.7 per cent; and ash, 1.7 per cent. If the above figures are calculated on a uniform basis of 75 per cent of water, the composition works out the same in the two cases; and it is also seen that liquid ostrich eggs contain less protein and more fat than average hens' eggs, though rather less of these ingredients than ducks' eggs. The report adds that the strong odor of liquid ostrich eggs may prevent their use for edible purposes, but that they might be useful for technical purposes in the forms of egg albumen and of preserved egg-yolk in the leather industry.—*South African Journal. Ind.*

Liquid Films

In a lecture before the Royal Institution on "Studies of Liquid Films" by Sir James Dewar, F.R.S., a summary of which is reported in *The Engineer*, the lecturer explained that their soap bubbles were blown with solutions of various soaps—ammonium soaps in quantitative chemical experiments because the determination of ammonia by Nessler's reagent was convenient, or soaps of the other alkali metals including caesium—containing up to 55 per cent of glycerin, and with various gases. The absence of dust, and especially of greasy dust specks, which reduce the surface tension, was essential for the long life of the bubbles. The liquid of the bubbles drained off continuously, and the films became thinner and thinner, the beautiful colors changing into silvery white and finally into black, the black film was visible only by a fluorescence and by reflecting the light. At the same time water vapor—the vessels in which the bubbles are produced always contain some water—was condensed on the film and absorbed by the glycerin, and the soap was thus washed out of the film, until the film practically consisted of water (98 per cent of water in one case); this dilution proceeded regularly, rapidly at first, then slowly. The gas pressure inside the bubble was always a little greater than the pressure outside. Owing to the surface tension the bubbles contracted, and the gas was forced outward through the film; the nature of the gas did not affect the stability of the film unless the gas (*e. g.*, carbon dioxide) reacted chemically with the soap. The contraction was slow in large bubbles and quicker in smaller bubbles of greater curvature, the rates of contraction and of gas transference being inversely as the diameter of the bubble. We reproduce some of the figures from Sir James' tables, slides of which were exhibited. The diameters D of the bubbles were given in centimeters; the internal pressure P signified the excess pressure in the bubble, measured in millimeters of mercury; the rate of transference R signified the gas transferred in cubic centimeters per square centimeter of bubble area per day. The bubbles were blown in air. We combine several series of experiments in one table. The liquid of series I contained 50 per cent of glycerin and 2½ per cent of caesium soap; in series II, 20 per cent of glycerin and 4 per cent of alcohol were in the soap solution.

—	I.			II.		III
Diameter D ..	6	7	8	10	12	38 cm.
Internal pressure P	0.3	0.26	0.23	0.18	0.15	0.05
Rate of transference R..	0.065	0.035	0.03	0.15	0.11	0.015

The next two series of experiments were made with hydrogen bubbles; in series IV the film was black, *i. e.*, as thin as it can be obtained; in series V the film was yellow and thicker. It will be seen that the amount of gas transferred was greater in the case of hydrogen than in the case of air, especially with the yellow bubble.

—	Hydrogen, Black Film Bubble. IV.			Yellow Bubble. V.		
D	6	8	10	4	6	8
P	0.3	0.23	0.18	0.55	0.36	0.28
R	0.253	0.218	0.19	0.285	0.103	0.05

In order to produce large bubbles of long life, Sir James continued, he had attempted to purify one of the cellars of the building of all dust, and to blow bubbles from outside through the wall; the cool, steady temperature of such a space would be an advantage for the experiments, which were disturbed by the heat and light beams of the lecture theater; but he had failed in these attempts. Yet he had produced and exhibited films, half black, and another wholly black, in a bottle, 0.5 m. in diameter, and also large black bubbles; one of these films had lived for 56 days in spite of all the vibrations of the laboratory. Bubbles were more difficult to preserve and their spontaneous contraction could be prevented by two methods, both of which had been applied: by replenishing the gas forced out of the bubble, and by producing the bubble in an atmosphere at high pressure the pressure being high both inside and outside the bubble. Showing a bubble in a glass vessel at 10 atmospheres, the lecturer pointed out that ten times the amount of gas would have to get through the film to produce the same contraction as would result in a container at 1 atmosphere pressure and hence that bubble did not appear to contract; in a container at 100 atmospheres the bubble would practically be permanent. A bubble produced under diminished pressure on the other hand contracted almost visibly. The flask used for this experiment was closed by a cap provided with two bores; through the one bore entered the blow tube, which was bent outside the flask so as to form a lateral pocket for a little soap solution, introduced through a stopcock from above; the gas in the bottle, air or other gas was rarefied by the aid of the tube passing through the other bore; the flask thus contained rarefied gas and water vapor. By tilting the flask while momentarily opening the stopcock a very small amount of air was admitted through a capillary tube and a little soap solution flowed down the blow tube producing the bubble which could be seen to contract. Still more striking was the next experiment. A soap film divided a cylindrical vessel into two compartments; the space on the left was filled with hydrogen, into the space on the right a little air was admitted. The image of the film was thrown on the screen where it showed as a black line; when the air was admitted that line traveled to the left because the hydrogen diffused through the film over to the right at a more rapid rate than the air diffused through it in the opposite direction.

The following table exemplifies the rates of transference of hydrogen through bubbles under pressures of 1 atmosphere and of 6.5 atmospheres. The first row again gives the diameters D of the bubbles in centimeters; the second the internal pressure excess P in millimeters of mercury; the third row expresses the P as fraction of the total pressure of 1 atmosphere, the fourth row as fraction of 6.5 atmospheres, in both cases with the coefficient 10^{-6}; the two last rows indicate the rate of gas transference R as before:

D	4	6	8
P	0.0331	0.022	0.0166
Fraction of total pressure .. (1.0 atm.)	43.6 ..	27.0 ..	21.5×10^{-6}
Fraction of total pressure .. (6.5 ,,)	6.7 ..	4.5 ..	3.25×10^{-6}
Rate R .. .. (1.0 atm.)	0.22	0.15	0.10
Rate R .. .. (6.5 ,,)	0.0825	0.041	—

Sir James then proceeded to demonstrations of the beautiful soap-bubble studies which Joseph Plateau initiated in 1842[1] and continued in spite of his blindness and the imperfect means at his disposal; his bubbles were very sensitive as the disturbing factors were not understood then. Plateau also experimented with drops of oil immersed in mixtures of liquids of the same density as the oil, in order to evade gravitation troubles (Sir James has also experimented on these lines), but he merely mentioned that similar experiments with soap bubbles would be very difficult, as they required gaseous media. Plateau had dipped skeleton crystals made up of thin wires into soap solutions and had studied the peculiar shapes the films assumed; these experiments were shown. When a cube is dipped into soap and withdrawn one should probably expect that the six cubical faces would be covered by films. That, we believe, is the first momentary effect. But the films are pulled inward and united in such a way that the center of the cube was taken up by a small square film (or a small cube), and that, looking at a cubical face, one saw four films joined to a truncated pyramid, the top of the pyramid being the little square. Similarly, the films of a tetrahedron contracted inward so as to meet in the center of the tetrahedron at angles of 120 deg. In the case of an octahedron there were 12 kite-shaped films crossing and meeting four small trigonal films, making altogether 16 films.

The lecturer then approached the problems in another way. Forcing air through a tube he produced a soap bubble on a plate of glass smeared with glycerin; the bubble was more or less hemispherical. When a second bubble was planted next to the first, the two united with a plane, common face; a third bubble added led to the formation of three common faces meeting at 120 deg.; and so on. When the plate was illuminated from below to show the arrangement in the plan, it was seen that five bubbles would group themselves about a pentagon,

six bubbles would form a hexagon, etc.; when the beam was sent horizontally through the bubbles, the beauty of their spherical and plane films could be seen. When the plate was blown upon, the films collapsed and flattened out, but the geometrical pattern remained discernible for a few moments. In order to study chains of bubbles, not resting on a plate, he made use of another arrangement, which is roughly indicated in the annexed diagram. By manipulating the stopcock drops of soap solution are allowed to flow down a glass tube; this tube is jacketed with a tube to which the air pipe is joined; below the soap tube the jacket is provided with a stricture; lower down it ends in a cylindrical glass nozzle, after passing through the top of a square glass case, nearly 2 ft. high, in which the device is mounted. The drop of soap solution splashes on the constricted glass, the aperture of which is dimensioned so as to admit the right amount of air, and produces bubbles. The bubbles came out of the nozzle like a long string of sausages, sometimes regular, of fairly equal sizes, apart from small bubbles dancing about and draining visibly all the time (in the inverted beam image they seemed to spurt energetically), sometimes irregular and dividing into multiple chains. Double chains, as in the diagram, seemed frequently to be formed in striking regularity; but photographs of catenaries of strange complexity, built up of multitudes of bubbles yet in regular patterns, were also shown. The chains of bubbles, when supported below by a ring, could be pulled out and inclined, and displayed considerable elastic strength. When properly thinned out, the bubbles were black; by admitting a little more soap solution from above the silvery tint, and colors were then made to reappear. The photographs had to be taken in sunlight—possibly because direct beam illumination would distort the images by too many reflections; stars of light shone on many of the bubbles. Some of the photographs in natural colors were particularly beautiful. They showed, *e. g.*, an inclined catenary in which both the spherical and the colored plane faces were very distinct; in other multiple chains black diamond faces stood out prominently from a mass of curved surfaces, visible only as black films, by their fluorescence. Very instructive were also the progress photographs. The first photograph of a series would show a string of bubbles of fairly equal sizes; on the second photograph the differences in sizes would be more marked, because the small bubbles had contracted more rapidly than the big bubbles; on the subsequent photographs the small bubbles would more and more vanish, the bigger ones uniting again, while even the latter had visibly shrunk.

Sir James concluded his discourse by quoting Roger Bacon. Bacon, who was very fond of referring to the ocean god Proteus, who could assume all shapes, had said that he, who would know the properties of water, would comprehend all that had been, that was, and that would be, although his knowledge would not extend to the individual beings. If water could by itself exist in this wonderful variety of shapes, Sir James remarked, the wonderful complexity of the shapes of living organisms ceased to be astonishing.

[1] See *Engineering*, February 2, 1916, page 109.

Methods for the Production of Pure Cocoanut Oil

The authors' experiments have shown that the oil cannot be readily expressed from freshly grated cocoanut, over 6% of the total oil remaining in the press-cake after being pressed at 1,000 lb. per sq. in. By treating the material with water and live steam for three hours before expression, 80% of the total oil is removed by a single expression. The resulting emulsion when heated as in the native process always yields a colored oil of burnt odor and taste, and no better results are obtained by heating the emulsion with salt, acids, or alkalis. The use of 10% sodium sulphite solution facilitates the separation, but the resulting oil is of inferior color and taste. The treatment might be useful, however, for the manufacture of soap stock oils. The best method is to chill the emulsion for 24 hours at 15° C., which causes the water to separate, leaving an upper layer of solid fat and cellular tissue, and also checks the development of moulds. After removal of the water the solid layer is melted at a gentle heat, and passed through a filter-press, and the filtered oil sterilized for 30 mins. at 100° C. and stored in air-tight vessels. Oil thus prepared has a pleasant odor, is free from acidity or rancidity, and keeps much better than ordinary copra oil. Another method is to dry the shredded coconut in a current of air at 70°—85° C. until its moisture is reduced to 10%, which is sufficiently low to prevent the formation of emulsions. The material will then yield over 80% of its total oil in one expression. Commercial copra press-cake is used for stock foods and for fertilizers, but the product obtained by the method described is sufficiently pure for human consumption. Meal prepared from it had the following composition:—Water, 7.35; oil, 32.14; ash, 4.05; crude fibre, 36.12; and proteins, 20.34%. It might be used with advantage as a substitute for wheat flour and lard in the preparation of edible products.—*Note in Journal Society of Chemical Industry on a paper by H. O. Parker and H. C. Brill in Philadelphia Journal Science.*

Note on the Testing of Magneto Magnets

By J. D. Morgan, A.M.I.C.E., A.M.I.E.E.

THE testing of the permanent magnets used in ignition magnetos, though apparently a simple matter, presents difficulties of both a scientific and a practical nature. On the scientific side there is no satisfactory criterion of magnetism which is peculiarly suited to magneto conditions, and on the practical side the usual laboratory methods are not readily adaptable to manufacturers' requirements.

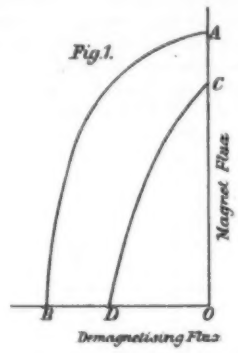
In simple, but not very definite language, a magneto magnet must possess both strength and permanence. As a measure of strength it is natural to think of remanence. As a measure of permanence coercivity at once suggests itself. With a good deal of reason in its favor the custom has therefore arisen among some users to specify magnets in terms of remanence and coercivity. For exact measurements of these quantities the ordinary processes of the physical laboratory are doubtless satisfactory, but for practical purposes they are inconvenient. This disadvantage is largely avoided, without materially affecting the accuracy of the results, by the instrument designed by Mr. E. A. Watson, of Coventry. In this instrument a nearly closed magnetic circuit, formed in part by the magnet under test, is provided with a narrow gap in which rotates a metal disk connected to a galvanometer. The galvanometer scale is calibrated in terms of the flux in the gap. By means of windings on the limbs of the magnet this flux can be varied as required. A typical curve is shown at A B, Fig. 1. It will be recognized that this curve forms a portion of the familiar hysteresis loop.

Having obtained the values of remanence and coercivity, the question arises: Can these figures be combined in a single figure which is suitable for defining the magnetic characteristics of the magnet? As is well known, the ratio of the two figures has been suggested, but this is obviously useless. The product has also been proposed, and, while it lacks definiteness, it may serve as a practical guide, because it is generally assumed that if a magnet of a given composition shows a certain remanence its coercivity will generally lie between known limits. Some uncertainty is, however, involved in a single characteristic figure of this kind, and if it is deemed necessary to specify remanence and coercivity it is better that they should be specified separately.

Remanence, by its definition, is unquestionably the correct measure of the so-called strength of a magnet, but whether coercivity is a proper measure of the ability of a magnet to retain its magnetism under practical conditions is not so certain. In the absence of any more definite measure it may be prudent to specify coercivity. The main reason for the doubt is found in the experience that increase of coercivity beyond that determined by the design of a particular magneto does not appear to be accompanied by any very practical benefits.

The writer recently developed a magnetic balance suited to practical conditions of testing and related in its action as nearly as possible to the duty which the magnet is required to perform. An instrument constructed for Messers. Thomson-Bennett Magnetos, Limited, to the writer's design is shown in Fig. 2. The scheme is illustrated diagrammatically in Fig. 3. A carefully poised beam *a* carrying a sliding weight *b* has secured to one end an armature *c* which is made from the magnetic portion of a megneto armature and fitted with the usual primary winding. In its normal position the beam rests on a stop which causes the edges of the armature to be separated from the adjacent horizontal edges of the cast-iron pole pieces *d* by air gaps of the thickness commonly provided between the armature and pole pieces of a magneto. The magnet *e* is slipped over the pole pieces as shown. The test is carried out by moving the weight along the beam until the pull of the magnet on the armature is just balanced. This gives a measure of the flux induced in the armature core by the magnet. Then the weight is returned to its zero position and current is passed through the armature winding. On increasing the current a condition is reached in which the opposing magnetism due to the current just balances the magnetism of the magnet, and the beam tips as if acted on by a weight. The reading on the ammeter *f* gives the counterbalancing current. If the test is carried out as follows a curve can be drawn. First the weight is moved to the position at which it counterbalances the magnet flux. Then it is moved a short distance along the beam towards the zero position and current is passed through the winding and adjusted until the beam is deflected. This operation is repeated at different positions of the weight until the latter reaches its zero position. The square root of the beam-scale readings is then plotted against current. A typical curve is shown by C D, in Fig. 1. The two curves are not drawn to the same scale; they are simply shown together to illustrate the argument given hereunder.

A characteristic of the test is that the permanent magnetism of the magnet should not be affected by it, or only slightly. This will be found by repeating the first part of the test after the current producing the opposing magnetism has been stopped. If variation be



shown, repetition of the test should bring the magnetism to a steady state. When, after repetition, both beam and current readings are below the permissible minima, the magnet is rejected.

It is evident that the area of the curve O A B (Fig. 1) represents the total energy put into the magnet. If an ideal machine could utilize the whole of that energy the area of O A B is the measure of the energy that would appear in the spark. Such a machine could, however, only give one spark, and before it could give another equal to it the magnet would require remagnetizing.

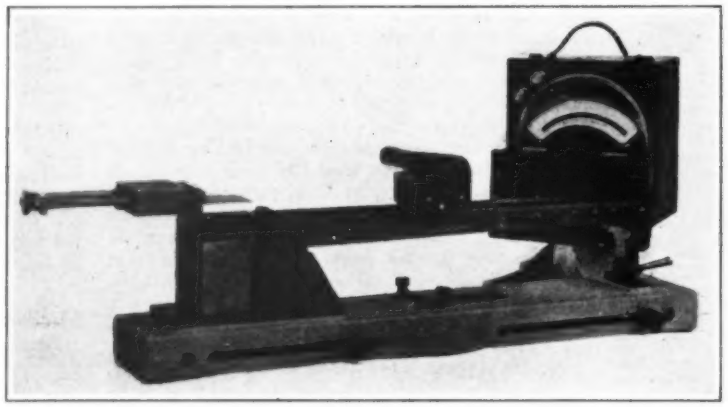


Fig. 2

The area O C D also represents energy, but as the same magnet is capable of reproducing the same curve indefinitely with remagnetization, it follows that the area represents the energy which an ideal machine can convert into a spark repeatedly without diminution. It is permissible, therefore, to compare the curves with the work diagrams obtained in stressing a metal bar (1) to the breakdown point and (2) to the elastic limit. The foregoing contains the reason for the statement in the earlier part of this article that increase of coercivity beyond a given figure does not appear to increase the durability of the magnet in its operation on a particular machine. Provided the coercivity figure of a magnet is above that corresponding to the maximum demagnetizing action which can be produced in the magneto, there is no apparent reason why this magnet should deteriorate in service.

An obvious criticism of the magnetic balance above described is that it does not exactly reproduce magneto conditions, seeing that the armature carried by the beam is situated above the pole edges instead of between the poles. The reply is that it is not possible to adopt the ordinary magneto relationship of the armature and pole pieces and at the same time obtain a perfectly definite indication of the state of balance when the proper demagnetizing current is applied. By arranging the armature in the manner illustrated this condition is avoided.—*From Engineering.*

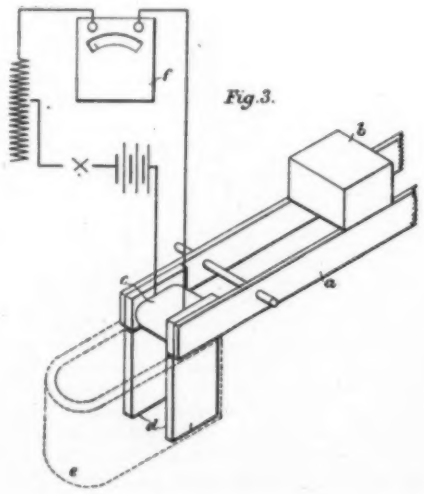


Fig.3.

The Commencement of the Astronomical Day

IT is probably known to most people that the astronomical method of reckoning time differs from the civil, the civil day commencing at mean midnight, while the astronomical day of the same date commences at the succeeding mean midday. The question as to the desirability of the uniform adoption of the civil day for both civil and astronomical purposes is one which is raised periodically. Laplace proposed the unification of the two systems as long ago as 1804, and his proposal was agreed to by the French Bureau of Longitudes, but no action was taken to carry it into effect. In 1884 the question was raised afresh at the International Congress at Washington, which decided in favor of unification. At a Congress at Geneva in the following year the resolution of the Washington Congress was the subject of a long discussion, and mainly through opposition from the German astronomers the matter was allowed to drop. The question was raised afresh a few years later by the Astronomical Society of Toronto, and again the French Bureau of Longitudes approved of the change. An able report on the *pros* and *cons* of the case by the late M. Poincaré is contained in the *Annuaire* of the Bureau of Longitudes for 1895 (a translation was given in the *Observatory*, 40, 323, September, 1917). For the change to be of value it is necessary that it should be adopted simultaneously by the governments which publish the principal ephemerides. This agreement has not hitherto been obtained.

The question has recently been once again brought forward by the Astronomer Royal and Prof. Turner. It may be thought that the question is one of mere academic interest. This is not so, as it would affect the various Nautical Almanacs. The change, in fact, is now advocated on account of the simplification which would result to navigators, who find the present system confusing and liable to lead to mistakes: Thus Capt. Fulton, of the Board of Trade, gives the following instance: To find the Greenwich date of the Moon's meridian passage on board ship, "one must enter the *Nautical Almanac* under the heading Meridian Passage (Upper), and, if in West Longitude, take the difference between the time of passage on the given day and the day following, or, if in East Longitude, take the given day and the preceding day, using simple proportion to find the time of passage at ship. This is a simple operation and easily remembered, but, as it refers to astronomical time, the observer must remember that the Moon passes the meridian after midnight during the half-lunar month, and he must, therefore, note whether the observation is A. M. or P. M. As an example, suppose a ship in West Longitude on, say, the 16th of July A. M., at ship then the dates for the meridian passage will be the 15th and 16th, and in East Longitude the 15th and 14th." It can readily be understood that the alteration to astronomical time before the application of longitude is a real stumbling block to many navigators.

Much has been said about the difficulties which would be caused to astronomers by the change. We do not think these objections have much weight except, perhaps, that a discontinuity would be introduced into astronomical records. For this reason it is desirable that the change, if adopted, should be adopted universally. Perhaps it would meet the case if civil time were to be adopted in the national ephemerides, and if astronomers were to agree to publish their observations in civil time.

The national ephemerides are prepared several years in advance, so that the change could not be made in any case for a few years. The matter is, however, under consideration by the Admiralty.—*Science Progress.*

The Southern Cross*

Isolina V. Millás

On a clear tropical evening, when the stars shining with unwonted brilliancy seem to be appealingly near, it is with a sudden thrilling sense of joy that the possibility of being able to accomplish a longer journey among them is realized. Gazing first at the constellation nearest to the present electrical pole, we commence our heavenly travel at Polaris, that most interesting of celestial bodies, and wandering through the well known and beloved constellations we go further and further southward, until suddenly a small constellation near the south celestial pole hovers into view; we are now gazing at Crux (the Cross) beautifully marked by the striking figure of the "Southern Cross," formed by the four brightest stars of the constellation.

Alpha is the only star of first magnitude; the others are of second and of third magnitude. The constellation is small, including an area of about seven degrees by four, but it is a brilliant one, and the neighborhood is

exceedingly lovely; in it are found stars such as alpha and beta Centauri, the first being the nearest of the fixed stars, at a light-distance of 4.3 years. Alpha Centauri is a telescopic binary; the two orbs revolve around a common center of gravity in 81 years. But slightly unequal in size, the brighter component is of special interest not only because it is the nearest neighbor of our Sun, but because it is also very similar to it in size and constitution.

This is also the region where Canopus shines forth, the leading star of Argo Navis; it is of the same type as Procyon, though enormously larger in size; notwithstanding the fact that it is at a distance of more than three hundred light-years, in brilliancy it is second only to Sirius.

In Argo shines the False Cross, larger it is true than the Southern Cross, but without its beauty and its cruciform aspect, due to a number of small stars within as well as near the outline. Between the two crosses, the attention of the observer is attracted by a lovely and interesting group consisting of six stars of fifth magnitude, ten of sixth, a cluster and a nebulous mass on which Eta Argo is to be found, the most remarkable of variable stars; it has passed from the fourth magnitude, as seen by Halley in 1677, to the first magnitude, and as such was recorded in Herschel in 1837.

In 1843, and from then on for several years, it shone almost as an equal of Sirius until, at last decreasing, it passed out of the field of stars seen by the unaided eye; but its changes did not cease then; in the latter part of the nineteenth century it was found to be a star of the sixth magnitude.

In this region shines the famous cross of the southern hemisphere, the most perfect of the heavenly vault, notwithstanding the fact that the outline is somewhat marred by a star of the fourth magnitude near an arm of the cross. Alpha marks the foot, and is within twenty-seven degrees of the south pole. It has a proper motion of 0".06, and is at a distance of fifty-nine light-years. This star and Aldebaran are considered as almost of standard first magnitude brightness; they are each 2.6 times more luminous than the pole-star. Still, Alpha Centauri, the lovely neighbor of Alpha Crucis, is superior to the latter; in fact α Centauri, Sirius and Canopus are the brightest stars of the skies, as they fairly outshine the three most brilliant of the northern hemisphere, Vega, Arcturus and Capella.

In the latter part of the seventeenth century, Alpha Crucis was found to be a double star; the astronomical work of some Jesuit missionaries, sent to Siam by Louis XIV, made it possible to include this star among the five double ones that were made known during that century. α Crucis is therefore of interest because it was one of the first few that pointed to the probable existence of systems unlike our own; a few who were willing to accept this, which meant a modification of things celestial as they were then known, commenced a real search for stellar doubles. Father Christian Mayer paved the way for the wonderful work of Sir William Herschel, who was able during the first years of the nineteenth century to give the necessary evidence of the physical existence of double stars. The brightest gem of the Southern Cross, viewed with magnifying power, is found to be composed of two stars, very brilliant and nearly equal, of 1.6 and 2.0 magnitude, about 5" apart; their small proper motion is supposed to be identical, due to the fact that, since their positions were determined in the early part of the nineteenth century, they have not preceptibly changed. Alpha Crucis as a binary is interesting because it is one of those couples which seem to possess, throughout the ages, a fixity all but absolute. This inactivity, so amazing, can only be explained by accepting for the stars that display it an exceedingly small mass, or a remoteness far beyond human comprehension. The first magnitude star of Crux has another small star undoubtedly belonging to it, of the seventh magnitude, 90" to the southwest. In 1891, Mr. Ranyard's attention was drawn to the position held by Alpha Crucis in the midst of a symmetrical little group of very faint stars which seem to form a corona for the brightest jewel of the cruciform constellation; investigations concerning these faint neighbors of α Crucis have led to the conclusion that undoubtedly there exists a physical relation between them.

Gamma Crucis is the head of the only real cruciform figure in the starry vault. It is a splendid red star of almost the same brightness as Betelgeux. Father Noël included γ Crucis in the number of red stars. Near this interesting constellation of the southern regions a star of the eighth magnitude was said by Sir John Herschel to be the most intense blood-red star of all he had ever seen; furthermore, comparing it with the beautiful whiteness of β Crucis he said that it was "like a drop of blood." Gamma Crucis is of 2.0 magnitude; it is also a double, its companion being a star of the fifth magnitude.

Beta Crucis shines forth as an arm of the cross; it is a notable oxygen star; in fact, it is known as McClean's "oxygen star"; it is a lovely white one, of which there are so many in the southern hemisphere. It belongs to the first of the two groups into which the first of Father Secchi's four types of stars was divided; this means therefore that it is a pure white star, that it is like those found chiefly in the Orion constellation, but not there only; the truth is that stars of this kind are found all over the sky, though in the southern hemisphere they are more numerous than in the northern, as was found by researches due to McClean. Another interesting fact about β Crucis is its remoteness from the earth; this was made evident when Dr. Elkin and Sir David Gill undertook the determination of thirty-two parallaxes, ten of northern hemisphere, twenty-two of the southern. In their work they found that five of the stars that shine most brilliantly in the heavens were inaccessible to parallactic research, and these were Canopus, Rigel, Spica, α Cygni and β Crucis. As each effort to determine the parallactic shifting of β Crucis has failed, its sublime magnificence and grandeur seem to dawn on the human mind. The necessity of taking into consideration the photometric rank, while trying to determine the distances of stars, has been demonstrated by the work carried on by Professor Kapteyn, who found it very convenient to distinguish between the stars of different spectral classes in order to obtain the best results. Although the spectrum presented by Canopus (α Carinae) shows the hydrogen lines of diminished width and the calcium K more pronounced, yet it cannot be considered of the solar type; it is of the Sirian, with a marked decline toward the solar.

Rigel is to be included in the list of helium stars, although of the later stages. Rigel has no proper motion that is observable, nor motion from or toward us. Spica is one of the most beautiful "landmarks" of the southern sky; it is a beautiful star of the "Orion type," and so distant from us, that, to be able to account for the intensity of its light, it is supposed to be at least one thousand times more luminous than our Sun. Deneb (α Cygni) has also been estimated to be at least a thousand times more luminous than our Sun; its distance from us is more than 400 light-years; its proper motion very small and its parallax imperceptible; it should be considered as an advanced star of the Sirian type. So these stars, among which Beta Crucis claims a place, so infinitely remote from us that they are inaccessible to parallactic research, are either helium or Sirian stars. Mr. Monck, speaking of this kind of stars, says that on an average they are twice as remote as solar stars of the same magnitude.

Near Kappa Crucis gathers the famous tinted cluster; the beauty of the different colors makes it appear, as Sir John Herschel said, a "gorgeous piece of fancy jewelry." The beauty of this variety of colors cannot be enjoyed with moderate telescopic apertures; it is only with the aid of larger instruments that this cluster thrills the observer as he catches the gleam of gems red, blue, green and yellow. Of course, the cluster does not appear the same to each observer, as is always the case when the color of stars is concerned; the red ones are easily distinguished, but not every observer that expectantly turns his gaze toward the splendid cluster of the Southern Cross is rewarded with the sight of the fainter tints; the gems that are supposed to stand out distinctly blue, green, yellow, in many cases shade off imperceptibly, only to seem drowned in white light. The respective places of a considerable number of these stars were determined first by Herschel and later by Mr. H. C. Russell. Some observers have insisted on seeing in many of these stars, heavenly bodies of extraordinary mobility. Of all the many, many clusters that beautify the heavenly regions, this cluster of the Southern Cross seems to claim a distinction; its beauty lies neither in shape nor in number, it is the beauty of the rainbow that it displays as its own.

A very interesting feature of the Southern Cross is the black opening of the Milky Way in this constellation, eight degrees long by five wide. It has very properly been called a "yawning abyss," and known by navigators of long ago it has even had its place in the popular stories that pass on from generation to generation, bringing into existence what is known as its folk-lore. MacPherson tells of how the "Coalsack" was considered in the folk-lore of Australia as the embodiment of evil; an Emu was fancied to lie waiting at the foot of a tree represented by the stars of the Cross, for an opossum which he persecutes, and which seeks refuge among the branches of that same tree.

The Milky Way, as it enters the Southern Cross, is no more than a stream three or four degrees wide; but it does not continue for long as we find it here; leaving the Cross it expands until it reaches nearly twenty-two degrees in the bifurcated section that stretches from Ophiuchus to Aquila.

The Coalsack and of course other galactic vacuities, found elsewhere but never so striking as this black opening of the Southern Cross, have stood out as it were to defy many theories that have tried to explain the complicated phenomena of what seemed, to the American Indian fancy, an appalling, mysterious "path of souls."

*Popular Astronomy.

Use of Crude Napthalene as Fuel for Internal Combustion Engines

The author describes a method of utilizing crude napthalene in an internal combustion engine of about 10 B.hp. installed in a motor launch. In the vaporizer used (designed by the author and G. G. Wilson) the molten napthalene does not pass through any pipes of small diameter or through a spray. This vaporizer is of the "surface" type and is self-contained, acting also as the fuel storage vessel. It consists of a rectangular exhaust jacketed vessel, built up of thin steel plate, all joints being oxy-acetylene welded. The apparatus is bolted to the top of an exhaust jacketed T-piece, the ordinary petrol carburettor being fitted to the bottom. The back pressure of the silencer is sufficient to force some of the exhaust gases round the vaporizer. The portion of the air which it is proposed to carburet approximately to saturation is drawn by the suction of the engine through the molten napthalene, the secondary air being drawn through the petrol carburettor, the jet of which is closed. The napthalene used in the experiments was crude, but of fairly good quality, extracted from coal-gas during the process of benzol and toluol recovery. The engine was run for five or ten minutes on petrol and when the napthalene had reached a temperature of about 130° C. the petrol was turned off completely. It was found that satisfactory running could be obtained by passing one-thirteenth of the air through the carburettor. Little difficulty was experienced with the carburation even with temperatures varying between 130° and 160° C. The calorific value of napthalene is 17,395 B.t.u. per lb. as compared with 20,100 and 18,700 for paraffin and petrol respectively.—*Note in Journal Society of Chemical Industry on an article by J. H. Willis in Gas Journal.*

Brush-Making Fibers

Piassava, the fiber from which certain brooms are made, is obtained from the various species of palms growing in Africa and tropical America. West African piassava is a brush-making fiber obtained from the leaf-sheaths of the wine palm (*Raphia vinifera*). It is produced in most of the British West African possessions, but chiefly in Sierra Leone. The imports of piassava fiber and other fibers for brush making into Great Britain in 1916 were 15,532 (long) tons, valued at $2,615,540. Among other brush-making fibers which are produced within the Empire are *Palmyra fiber* and *Kitul fiber* the latter being prepared from the kitul palm of India and Ceylon.

A Review of Mycology—I*

Questions of Biology That Still Demand Study

By P. Vuillemin, Correspondent of the Institute and Member of the Faculty of Medicine at the University of Nancy

First Part: Cytology

IT would be easy to pile up related facts in a mass of notes concerning the various branches of Mycology. We prefer to confine ourselves to the questions of Biology which still demand to be studied and to weigh, in the recent works of mycologists, the data which may enable us to solve these. We have chosen two of these: Cytology and Symbiosis.

Among the problems to be considered in Cytology we shall deal with three: I. Debatable questions of system upon which light is thrown by cellular structure; II. Cytological indices of sexuality; III. Cytological characters depending upon secretion.

I. CYTOLOGY APPLIED TO SYSTEM

The affinities of the Peronosporeae with the green Algae of the group of Siphoneae receive a fresh confirmation from the researches of W. Himmelbaur[1]. The false dichotomies, the peculiar mode of thickening of the membranes, are characters common to the *Phytophthora* and to the *Vaucheria;* the author also compares the papilliform prolongation of the spores of the Fungi to those of the autheridia of the Algae.

It is no longer believed, with Bary, that the Fungi form a continuous series, starting with the Siphoneae and passing progressively though the Phycomycetes to the Eumycetes. Their points of contact with the Algae are multiple.

Griggs[2] finds in cytology reasons sufficient for withdrawing the *Rhodochytrium* from the confused mass of the Archimycetes and connecting it with the Protococcoids by the intermediary stage of the Phyllobium. The cytological resemblances between *Rhodochytrium* and *Synchytrium* suggest the idea that the Synchytriaceae derive from the same Algae. The profound study of the cytology of the *Synchytrium* made by Mme. G. Tobler-Wolff[3] accentuates the differences of this genus with respect to the true *Chytridiaceae.*

Among the signs of affinity between the Eumycetes and the purple Algae the structure of the membranes is often referred to. The floridian character of the thallus is exaggerated in a lower group of Ascomycetes studied by Mangin and Patouillard[4] under the name of Atichales. The alliance comprises the genera *Seuratia, Phycopsis,* and *Atichia,* they are less characterized by the asci, unknown in the third genus, whose name they have taken, than by the mucilaginous thallus, multiplying by a sort of budding and forming propagnles variously arranged. It would scarcely be correct to speak of a true mycelium. Without refusing to the *Atchiales* the designation of aberrant Ascomycetes, the authors believe that this group has retained, in the vegetative apparatus, ancestral characters which prevent its being joined with the Eumycetes.

An inclusive study upon the Protomycetaceae of Switzerland,[5] preceded by two preliminary notes,[6] provided G. Von Buren with occasion for substituting for the *Hemiasci* of Brefeld the better defined group of the *Protoascineae.* Du Bary had remarked certain concordances between the *Protomyces* and the Ustilagineae; in fact, the two groups are parallel; according to Von Buren the Protoacineae occupy the same place in the Ascomycetes series as the Ustilagineae in the Basidiomycetes series. The Protoascineae are distinguished by the absence of ascogneous filaments interposed between the elements functioning as gametes and the ascus. The *Dipodascus* answers to this description as well as the *Eremascus, Endomyces,* and *Saccharomyces.* The fructification, encysted in the beginning, forms a chlamydospore characteristic of the Protomycetaceae. In the *Protomyces* the young chlamydospore contains several nuclei which divide and then seem to be fused in couples, after which they are crowded towards the periphery by the vacuoles invading the center; the parietal stratum splits up into uninuclear portions each of which yields four spores. The chlamydospore differs from the typical ascus not only by the encystment, which is an accessory phenomenon, but also, and especially, by the plurality of the conjugated nuclei whence proceed the spores. It is not a simple ascus, but a *synascus,* well characterized in the genera *Protomyces, Protomycopsis,* and *Taphridium,* and less precisely in the genus *Vollkartia,* in which the entospores are born without order in the chlamysospore.

The naked asci are primitively plurinuclear in the *Dipodascus,* and this is sufficient, in the eyes of Von Buren, to lead to the conclusion that it has peculiarly close affinities with the Protomycetacea. But let us not forget that of all these nuclei, but a single pair, it is believed, has a direct part in the formation of spores.

The new genus *Protascus,* created by P. C. Van der Wolk,[7] has asci with two or more irregular nuclei. The type-species, *Protascus colorans,* colors grains of rice yellow shading to orange or to brown.

There are discordant opinions on the subject of the affinities of the Gymnoasceae. G. Arnaud[8] withdraws the *Eremothecium* from these to liken it to the *Protomyces.* He inclines to see in the *Nematospora Coryli* a state of development of the same genus. Since the publications of Von Buren we are justified in demanding positive arguments in support of such hypotheses. Moreover, Sartory and Bainier[9] lightly decide the affinities of the Gymnoasceae in placing them among the Discomycetes.

In our last Review of Mycology[10] we stated that the genus *Endogone* was restored by Bucholtz from the Hemiasceae to the Physomycetes, probably to the Mucorineae. The Russian savant does not adhere to this. In three new notes Bucholtz[11] minutely examines the structure of the *Endogone lactiflua.* The hypogeal fructification is protected by a network of degenerate filaments in the internal strata; it is a *zygosporocarp.* The beginning recalls the formation of a zygospore of the Mucorineae; two similar filament sinosculate at the top, and each isolates a gamete by a partition, after which the nuclei, at first multiple, have emigrated, with the exception of a single one, in each suspensor. In the Mucorineae the zygospore takes the very place of the gametes; here one of the gametes empties into the other, which marks a sexual differentiation between the equal gametes. The two nuclei, without blending, pass together into an excrescence of the female gamete; the excrescence enlarges, thickens its membrane, invests itself with the above mentioned cortication; the two nuclei remain independent until maturity; the caryomixia does not take place before the germination which has not been regular.

Assumedly these characters separate the *Endogones* from the known families. Bucholtz sees in the *Endogoneae* an intermediary term between the zygometes and the Oomycetes. On his part, K. Kavina,[12] though he has not succeeded in observing either conjugation or heterogamy, does not hesitate to inscribe among the Phycornycetes a new family, the *Endogonaceae.*

The problem is necessarily enlarged if we take into account the insufficiency of the classification, in which a large number of well known fungi refuse to be comprised. Take for example the Entomopthoreae. If we accept as a distinctive difference between the Phycomycetes and the Eumycetes, the absence of partitions in the one and their presence in the other, we shall dismember what is evidently a natural group by putting the *Empusa Muscae* among the Phycomycetes, the *Empusa Sciarae* among the Eumycetes. In this same family the sexual fructifications are chiefly zygospores or azygospores; but the *Empusa sepulchralis* presents, like the *Endogone,* copulatrix branches, one of which empties into the other from which issues a durable spore by lateral budding. However neither Thaxter nor any other mycologist has had the slightest idea of seeing in this fact a sign of affinity with the Oomycetes. Why not? Because the Oomycetes are less characterized by their eggs than by the ensemble of their structure, and especially by the zoospores, which are lacking in the Entomophthoreae as well as in the Endogonaceas.

For the same reason we do not dream of assimilating the Endogonaceae with the Antomophthoreae, which differ from them in structure as well as in facies; but we do not deem it necessary to place either of these groups among the Phycomycetes. The mode of formation of the fructifications, so admirably set forth by Bucholtz, reminds us at once of the Mucorineae and the Ascomycetes, especially the Protoascineae.

II. CYTOLOGICAL INDICES OF SEXUALITY

Sexuality is characterized by the association of two cells. It has for its result the fusion of these two cells into a single one and the constitution of a zygote or egg.

The nuclei, forming the most circumscribed portion of the cell, furnish the best cytological index of sexuality. Among the fungi, in which the more superficial prepatory acts—the coupling of two individuals, two organs or two filaments—are often lacking, we always recognize the sexual act in the *caryogamy,* or coming together of two nuceli, and its results in the *caryomixia,* or fusion of two nuceli into a single one.

Caryogamy, the index of the essential act of fecundation, is necessarily accomplished in the interior of a cell; we can not therefore properly speak of an exocaryogamy in contrast to endocaryogamy. But it is permissible to distinguish between endogamy, comprising caryogamy, preceded or not by internal sexual phenomena, and exogamy, *i. e.,* apparent exterior coupling. We will examine successively three things in the fungi: A, the passage from exogamy to endogamy; B, the conjugated nuclei, the expression of caryogamy; C, the cases in which caryogamy and caryomixia are independent of sexuality.

A. *Passage from Exogamy to Endogamy.* Exogamy, or the copulation of sexual organs separated exteriorly, either upon two plants or upon an androgynic plant, is as rare among the Eumycetes as it is frequent in the Algae and the Phycomycetes. Several new examples have recently come to light in the groups considered as branches detached previously from the stock either of the Ascomycetes or of the Basidiomycetes.

In the first type the copulation unites two spores, issuing immediately or almost immediately from the zygote. To the list of the yeasts in which Guilliermond had observed the copulation of ascospores, H. Marchand[13] adds the *Saccharomyces ellipsoideus, validus, intermedius, turbidans.* The coupling is reported at the moment of the formation of the ascus in the genus *Zygosaccharomyces,* so that the nuclei brought together by caryogamy are instantly fused by caryomixia. In the *Zygosaccharomyces Chevalieri,* isolated by Guilliermond[14] in the ginger wine of East Africa, the copulating globules are unequal; we have here, therefore, both exogamy and heterogamy at the same time.

It was already known that the spores of *Protomyces,* like those of *Taphridium,* were coupled after their emission, but they were believed to be plurinuclear. G. Von Buren[15] has proved that they have a single polar nucleus, at least so long as they are contained in the ascus. Copulation is lacking in the related genus *Protomycopsis.*

In the Ustilagineae Rawitscher[16] follows closely the copulation of the sporidia of *Tilletia,* the equivalents of basidiospores. One of the copulated sporidia empties itself into the other; we find again two conjugated nuclei dividing themselves conjointly in each cell of the filament issuing therefrom.

The second type of exogamy, recalling the purple Algae, or Florideae, is represented by male gametes deprived of motility of their own, the spermatia, and by a female organ ending in a filiform tube, the trichogyne, through which the contents of the spermatia adherent to its surface travel toward the oogone. This type is normal among the *Laboulbeniales* still manifested in various Lichens; traces of them are also found in other Ascomycetes and in the Urindineae, but these specimens of a vanished period have lost their function and replaced it by the endogamy which is accomplished at a period and at a place more and more remote from the epoch and the locality of primitive copulation.

The *Laboulbeniales* have sexual organs resembling externally those of the Florideae to such a degree that mycologists hesitate to place them among the Eurycetes. J. H. Faull[17] has demonstrated that these are really Ascomycetes; he fixes their systematic position by forming a subdivision of the Pyremycetes for this group. The single nuclear fusion takes place in the young ascus; it is preceded by a stage of conjugated nuclei whose origin can be traced to the carpogenic cell. A

*Revue Generale des Sciences (Paris).

[1] Proceedings of Royal and Imperial Zool.-Bot. Soc. of Vienna, vol. LXXII, 1912.

[2] Botanical Gazette, vol. LIII, 1912.

[3] *Arch. Protistenk.*, vol. XXVIII, 1913.

[4] C. R. Ac. Sc., vol. CLIV, 1912.

[5] Report on Cryptogamic Flora of Switzerland, vol. I, Bern, 1915.

[6] *Mycol. Centralbl.*, vols. IV and V, 1914.

[7] *Mycol. Centralbl.*, vol. III, 1913.

[8] *Bull. Soc. Mycol., France,* vol. XXIX, 1913.

[9] C. R. Soc. Biol., vol. LXXIV, 1913.

[10] *Rev. Gen. d. Sc.*, Mar. 15, 1913, p. 189.

[11] New Report on the Morphology and Cytology of the Subterranean Fungi Frutcification. *Endogene,* Riga, 1911.—*Beih. Bot. Centralbl.*, vol. XXIV, 1912.—*Korrespondenzbl. Naturw. Ver. Riga,* 1912.

[12] On the Systematic Position of the Genus *Endogene,* 1915. This Bohemian work is known to us by Stuchlik's Analysis, Bot. Centralbl., vol. CXXIX, 1915.

[13] C. R. Soc. Biol., vol. LXXII, 1912.

[14] *Ann. Sc. nat. Bot.*, 9th series, vol. XIX, 1914.

[15] *Mycol. Centralbl.*, vol. V, 1914.

[16] *Ber. deutsch. botan. Geo.*, vol. XXXII, 1914.

[17] *Ann. Botany,* vol. XXV, 1911.

single point in the nuclear evolution remains obscure; it is that at which the external appearances are the most favorable to exogamy; in fact the association of the nucleus of the antherosphere with a nucleus of the female apparatus has not yet been observed.

Apogamy is evident in the *Laboulbenia chaetophora* and the *L. Gyrinidarum*, in which the absence of the antherosphere is pointed out by Faull.[18] The first conjugated nucleus is furnished by a trichophoric cell and a carpogenic cell brought into communication by the destruction of the median partition.

The habitat of the *Laboulbeniales* upon the bodies of tracheiferous Arthropods contrasts with the habitat of the Floridese, which abound in vast depths. But the choice of a host is far from being strictly limited. The genus *Rickia* is remarkable for its indifference; the same species lives on the Coleoptera and on the Acarians which attack these. The insects, various Coleoptera, ants, etc., which serve as hosts for the *Rickia*, live in community with the Acarians. R. Maire,[19] concludes from this that the Acarians have become propagators of the *Laboulbeniales*, colonized at first upon certain insects; he also finds the *Rickia* among the *Scaphidiidae*, Coleoptera until now considered immune.

The recent publications of R. Maire (1912-1916), Picard (1913), Cépedè (1914), Thaxter (1914–1915), Spegazzini (1914-'15-'16), have lengthened the list of the hosts of the *Laboulbeniales* still more, while denoting many details of the morphology of these fungi. The Crustacea do not figure among their hosts, for Maire[20] relates the Thaxter *Amphoridium* to the parasites pointed out by Racovitza on the terrestrial Isopods.

If the affinities of the *Laboulbenailes* with the Floridese are not illusory it would be of the highest interest to discover among them marine representatives having living Crustacea as hosts instead of purple Algae. In 1908 Picard made known the first marine Laboulbeniaceae. We are inclined to relate to the same group the *Thalassomycetineae*, enigmatic fungi living under the belly of the pelagic Decapods of the genus Pasiphæa. E. A. Niezabitowski,[21] the author of this remarkable discovery, describes two species, *Thalassomyces* and *Th. Batei*, found, the first in the Mediterranean at depths varying from 90 to 1,000 meters, the second in the Pacific Ocean on Crustacea taken at a depth of 576 meters. In the absence of sexual organs and of zoospores we do not see upon what basis the author rests his opinion, which places the new family among the Oomycetes in proximity to the *Monoblepharideae* and the *Saprolegnieae*. From the pedicle implanted upon the carapace issue moniliform filaments several times divided by dichotomy; the last branches terminate in an apparatus regularly formed of an elongated basal cell and of three rounded cells regarded without proof as conidia. Each of these apparatuses has its equivalent in the *Laboulbeniales* in the form of the quadricellular external thallus, which, proceeding directly from the ascospore, constitutes the entire vegetative apparatus of the majority of the species, the sexual organs proceeding from the two inferior cells. The dichotomous filaments do not differ from the dichotomous rhizoids of the *Trenomyces* except by their external situation. The mode of fixation upon the host is the same as that of the *Laboulbeniales*. We confine ourselves to suggesting these points of comparison, which only a completer knowledge of the parasites of the Crustaceae can confirm or discredit.

The relationship of the Uredineae with the Floridese is briskly combated by Mme. Moreau. While considering the spermatia as male gametes which have become useless, Mme. Moreau[22] sees in the ecidia a sporiferous organ and not a female organ. In the *Phragmidium subcorticium* each vasal cell, before becoming the mother of the ecidiospores, gives issue to a chain of uniculear cells. Blackman compares these to the trichogyne; Mme. Moreau sees in this ostensible trichhogyne female gametes which at present do not function. Both authors agree upon the essential point: whether functioning or inactive, the cells of the trichogyne and the gametes are homologous elements characterized by a single haploid nucleus.

In a remarkable comprehensive study of the phenomena of sexuality in the Uridineae, Mme. Moreau[23] gives the name pre-accidiospores to the uninuclear cells which exist at the base of the perfect aecidia of the *Puccinia Vilaeo*, as well as at the base of the aecidia of the *Phragmidium* corresponding to the inferior organization of the ecomas. According to the hypothesis of the author the primitive Uridineae should have functional spermatia, and, as a pendant, conceptacles of female gametes similar to the pre-aecidiospores which in actual aecidia are ruined gametes. These hypothetical female conceptacles are called pre-aecidia.

In Mme. Moreau's opinion endogamy, substituted for exogamy, comprises two beginning phases, the first by cytogamy, the last by caryogamy. Cytogamy is the uniting of the cytoplasms of two cells; the separate nuclei in the same cell form a dicaryons. Caryogamy is the uniting of two haploid nuclei and a diploid nucleus in the telentospore, the author not accepting the theory of the synergy of the simultaneously dividing conjugated nuclei which form the dicaryons. Between the haplophase, wherein cell and nucleus are simple, and the diplophase, wherein they are double, we intercalate a dicaryophase wherein a double cytoplasm contains two simple nuclei.

Cytogamy would appear to be unnecessary in the ecidia, since that of the *Erdophyllum Euphorbial* var. *Uninucleatum* has no dicaryons, and since these are found in the *Uromyces Scillarum* deprived of ecidia. Madame Moreau concludes therefrom that this phenomenon has lost contact with the primitive point of departure of sexuality in the *Uredineae*.

It is extreme to refuse all initiative to the nucleus in the pretended cytogamy. Welsford[24] confirms the ideas of Blackman by proving that the first binucleated cell of the *Phragmidium violaceum* has received one of its nuclei from any adjacent cell.

Various lichens have typical spermatia and trichogynes whose union has been often proved. In the *Collema pulposum*, studied by Mme. Bachmann[25] small numbers of spermatia are attached to filaments below the surface of the thallus. The trichogyne, in place of erecting itself from the surface, obeys the chemitactism which attracts it towards the immobile spermatia; it elongates itself until it is in contact with these male organs, with which it unites itself before the formation of the asci.

Among the independent Ascomycetes of the Algae, the *Venturia inaequalis*, the ascosphorous stage of the *Fusicladium dendritieum*, a parasite of the pear tree and the apple tree is the object of the investigations of Killian.[26] In the tissue of fallen leaves a filament sends forth a lateral branch rolled into a spiral. The latter elongates itself and branches; the internal cells constitute the ascogenous filament, whose terminal cell elongates itself into the trichogyne, passing beyond the sheath formed by the external cells. The hyphae starting from the sheath or its vicinity finally envelop the trichogyne; the author considers them to be antheridia. Towards the middle of December the trichogyne sends forth excrescences which apply themselves to the antheridian branches; the median wall, dotted with perforations, lends itself to the irruption of the male nuclei into the trichogyne, and thence, by analogous sieves, into the large central cells. The asci and the paraphyses appear a month after the bringing together of the antheridian branches and the branches of the trichogyne; but we lack precise knowledge on the subject of the migrations and the evolution of the nuclei.

The structure of the archicarp of the *Lachues Carnea* investigated by Mrs. H. C. I. Fraser,[27] is no less favorable to the migration of the nuclei, for the partitions which separate the multiple cells of the trichogyne are perforated with pores contingently provided with a callous pad; large pores bring into communication the cells of the rolled up filament which constitutes the ascogne; but no contact being established between the archicarp and its sheath whence the trichogyne issues, no filament can be regarded as belonging to a male organ capable of approaching the trichogyne and accomplishing exogamy.

The *Polystigma rubrum*, long cited as the classic example of the union of the spermatia with trichogyne in the Ascomycetes, has been made a new subject of research by Blackman and Welsford[28]. The spermatia and the trichogynes are abortive sexual organs; the first show signs of nuclear degeneration before leaving the spermogonia; the analogus filaments of the trichogynes are vegetative organs unrelated to the ascogones; we perceive conjugated nuceli as soon as there is differentiation of the ascogenous filaments; the nuclear fusion is accomplished in the young ascus.

In accord with the English authors in affirming the degeneracy of the trichogynes and the spermetia, W. Nienburg[29] does not ignore their value as bearing witness to a past state, parallel to that which persists in the *Collema*. Without lingering over retrospective views he defines the nuclear evolution ending in the union of two nuceli in the ascus. The archicarp rolled up spirally comprises a single row of cells; the lower two, which are voluminous, are distinct from those following, which are narrow and ephemeral. The second is an ascogone provided with large nucleus; the first is an antheridium having several nuclei; a single nucleus of the antheridium passes into the ascogone; the two united sexual nuclei form the first pair of conjugated nuclei. After several manipulations of its contents, the fecundated ascogone sends forth complicated tufts of ascogenous filaments, of which every cell is binuclear. The adjacent vegetative cells of the archicarp send out protective paraphyses.

Nienburg believes that the association of uninuclear ascogone and a plurinuclear antheridium constitutes a new type of sexual apparatus for the Ascomcetes; he finds an analogous case only in the oogone and the antheridium of the Monoble pherideae. It is useless to wander into such remote comparisons.

The uninuclear ascogone does not differ essentially from that of the *Floridiae*, the *Laboulbeniales*, the Lichens furnished with a trichogyne. The following cells contain several nuclei, whose number increases in proportion as they recede from the ascogone, attaining the maxi num in the trichogyne which is often branched; these plurinuclear elements are the first signs of atrophy which first reveals itself in the lack of partitioning after the nuclear divisions, and soon after by the premature death of the trichogyne without having functioned. The nale apparatus undergoes the same parallel retrogression as the female apparatus to the extinction of exogamy. Among the Floridiae the numerous uninuclear antheridia are borne upon branched filaments; those of the *Laboulbeniales* are almost sessile and pass into composite antheridia in which the antherogoides collect under the ostiole as in a plurinuclear cell. The external and branched antheridian system of the *Venturia* becomes uselss in the *Lachnea*. The *Polystigma* dispenses with superfluous ramifications; the basal cell is the seat of repeated division of the nucleus but is not itself partitioned; it represents all the ramifications and all the cells of the male system condensed at the contact of the ascogone. This example shows exactly how endogamy is derived from exogamy.

P. Claussen[30] has proved, in the *Pyronema confluens* the penetration, vainly sought for by Dangeard, of the nuclei of the antheridia into the oogone. The male nuclei are not immediately fused with the female nuclei, as Harper believed; they form conjugated nuclei which pass into the ascogenous filaments, and divide together and then unite definitely in the young ascus.

Among the Erysiphaceae the passage of the nucleus of the antheridium into the oogone has been alternately affirmed and denied. It has been directly observed by Bezssonoff[31] in the *Spaerotheca Astragali*. The same author detected two nuclei in the oogone of the *Spaerotheca Mors-Uvae* after the disappearance of that one of the nuclei proceeding from the mitosis of the antheridian nucleus; shortly after the oogone contains four nuclei; the author does not consider himself competent to decide whether the male nucleus is united to the female nucleus before a double bipartition or whether it divides like the latter.

B.—*Conjugated Nuclei, the Expression of Caryogamy.*

From all the facts previously related it results that, in the Uredineae, the Ustilagineae, and the Ascomycetes including Lichens and Laboulbeniales, the constitution of the conjugated nuclei (the dicaryons of Maire and of Mme. Moreau) is the immediate effect of the exogamy or of the endogamy which replaces it. This is not a simple cytogamy; this term is in contradiction to that of dicaryophases proposed at the same time by Mme. Moreau to designate the period characterized by the conjugated nuclei. The active participation of the nuclei is indisputable when one of the n proceeds from a differentiated male organ; in all cases their synergy is more manifest than that of the cytoplasms, which is not contested; it is therefore at least as much a caryogamy as a cytogamy. The confusion proceeds from the various extensions attributed to the meaning of the word caryogamy, under which term three different acts have been included: namely the sexual coming together of the two haploid nuclei, their union in a diploid nucleus, and finally the return of the diploid nucleus to the haploid type. The school of Dangeard restricts the name of caryogamy to the second act; R. Maire is more correct in confining it to the first, and in giving to the following one the name of caryomixia.

The conjugated nuclei make their appearance in the ascogone, which is at first uniculear of the *Peckiella lateritia* studied by Moreau[32]; Ramlow[33] distinguishes them in the ascogenous filaments proceeding from the

[18] *Ann. Botany*, vol. XXVI, 1912.
[19] *Bull. scient. France et Belg.*, 7th series, vol. XLIX, 1916.
[20] *Bull. Soc. hist. nat. Afrique du Nord*, vol. VII, 1916.
[21] *Kosmos*, vol. XXXVIII, Lemberg, 1913.
[22] *Bull. Soc. Mycol.* France, vol. XXX, 1914.
[23] Thesis, Paris, 1914.
[24] *Annals Botany*, vol. XXIX, 1915.
[25] *Annals Botany*, vol. XXVI, 1912—*Arch. Zellf.*, vol. X, 1914.
[26] *Ber. deutsch. botan. Ges.*, vol. XXXIII, 1915.
[27] *Annals Botany*, vol. XXVIII, 1913.
[28] *Annals Botany*, vol. XXVI, 1912.
[29] *Zeitschr. Botanik*, vol. VI. 1914.
[30] *Zeitschr. Botanik*, vol. IV, 1912.
[31] *Bull. Soc. Mycol.* France, vol. XXX, 1914.—*C. R. Ac. Sc.*, vol. CLVIII, 1914.
[32] *Bull. Soc. Botan.*, France, vol. LXXI, 1914.
[33] *Mycol. Centralbl.*, vol. V, 1915.

plurinuclear ascogone of the *Ascophanus carneus*. Carruthers[34] perceives them only in the hypothecium of the *Helvella crispa*. Often, as we know, there is only one dicaryon in the crotch which bears the ascus.

The Basidiomycetes, like the other Eumicetes, have a dicaryophase. External vestiges of the differentiation of the sexes are rare and disputed in this superior group; it is all the more instructive to determine the relations of position between the first conjugated nuclei and the supposed spermatia of the Coprinae. This is the principal point of interest in the memoir of Kneip.[35] The basidiospore of the *Coprinus nycthemerus* germinates in a plurinuclear vesicle; the filaments which proceed therefrom have cells whose single nucleus is haploid; from it there separate rods, which are probably vestiges of gametes which have lost their function and at present constitute haploconidia. Sometimes the whole mycelium retains the simple character, the conjugated nuceli appearing in the first rudiment of the receptacle. More often the conjugated nuceli reveal themselves in the course of the mycelian development; when the mycelian dicaryophase is prolonged it is complicated by the formation of rings uniting the consecutive binuclear cells. Kneip[36] has come back to the cytology of these enigmatic organs which are so widely found among the *Hymenomycetes*. The ring cells have two conjugated nuclei; the ring appears at the periphery of the terminal cell in the form of an excrescence situated at an equal distance from the two muclei; the excrescence curves inward toward the preceding cell; each nucleus undergoes a mitosis in such a way that there are two apical nuclei and two basal nuclei; one of the apical nuclei serves in the ring as an isolated partition; a transverse partition separates at the same time the two basal nuclei; the ring proceeds to open underneath this partition, and the migrating nucleus penetrates into the new subterminal cell. The nuclei of the new couple have a relationship therefore which is a degree more distant than the conjugated nuclei from which they proceed.

The author compares the formation of the rings of the Basidiomycetes with the formation of the hooks in the Ascomycetes. We invite attention also to their resemblance to the biped support of the sporiferous sacs of the *Dipodascus*. The example of the Hymenomycetes furnishes further information: the formation of rings is independent of the appearance of conjugated nuclei; by the exchange of nuclei it achieves a supplementary correction of the lack of exogamy. To return to the Coprin, it coincides, like the formation of conjugated nuclei, with the period when the supermatia, probable vestiges of the suppressed exogamy, exhibit themselves.

In the *Hypochnis terrestris*, a new species studied by Kniep, in the *Cyathus Olla* studied by Malinowsky[37] as well as in the immense majority of the Basidiomycetes, the first conjugated nuclei appear in the basidiospore; the haplophase, therefore, comprises at most the two dimensions of the nucleus of conjugation of the basidium.

The shortening of what it is the custom to call the gametophyte scarcely seems likely to exceed this limit. However, in an Agaric of Tonkin which Patouillard[38] has been led to inscribe among the *Pasthyrella* the gills are laden with bulbils which the nuclear evolution studied by Moreau[39] leads us to regard as encysted basidia. The two nuclei, distinct at the beginning, become fused; the diploid nucleus divides into two parts by typical mitosis, restoring the simple type; a second mitosis is followed by the degeneration of two of the four nuclei, which brings the cells back to the binuclear type.

C.—*Caryogamy and Caryomixia foreign to Sexuality.*

Outside the phenomena connected with sexuality, plurinuclear cells are encountered or, if we restrict the idea of the cell to the presence of a single nucleus, polyenergidian elements, not only among the Phycomycetes, but also in various Eumycetes. We have cited examples of them among the *Pyronema*, *Polystigma*, *Protomyces*, etc. The four ascospores of *Podospora anserina*, according to Wolff[40], each enclose two nuclei, while its congeners possess 8 or 16 uninuclear spores. This case differs essentially from that of the basidiospores with two nuclei, since the membrane of the ascospore has united two nuclei previously separated while the basidiospore was at first provided with a single nucleus. Moreover, the ascospore germinates in haploid filaments, while the basidiospore inaugurates the stage of conjugated nuclei which will come to an end in the new basidia. The conjugated nuclei are distinguished not only by their coming together and their simultaneous division, but also and especially by the period of ontogeny which characterizes them.

The uniclear fusion, the caryomixia (caryogamy of Moreau, etc.), is independent of sexuality when it does not prepare the return of the diplophase to the haplophase. Moreau[41] has pointed out the vegetative fusions of the nuclei in the columella of *Zygorhynchus Dangeardi*. In his researches upon *Ascophanus carneus* Ramlow[42] determined that one portion alone of the nuclei of the ascogone emigrates by pairs into the ascogenous filaments; the others swell up; often several flow together and form large vesicles with two or three nucleoles; these are the supposed zygotes of Miss Fraser. In fact they degenerate on the spot.

Miss Keene[43] describes phenomena of the same kind in the Mucorineae. In the zygospore of *Sporodinia grandis*, the nuclei which have had no part in the regular formation of zygotes are digested by the confluent Elæoplasts, formerly taken by Léger for embryogenic spheres; by Dangeard for chromatic corpuscles; by Lendner for large copulative nuclei. In the same way, according to Schürloff,[44] there are in the asparagus stalk giant nuclei resulting from the nuclear fusion which serve as materials, with the cells which contain them for the construction of vascular fascicles.

We find, therefore, throughout the whole extent of the vegetable kingdom associations and fusions of nuclei, caryogamies and caryomixias quite distinct from the similar images which mark the stages of sexual evolution.

III. CYTOLOGIC CHARACTERS DEPENDING UPON SECRETION

Living cells contain substances separated from the protoplasm by the secretive function. Among the Fungi it is rare for the intra-cellular secreting organs to be as clearly defined as the plasts or leucites of green plants. On contact with solid or liquid inclusions protoplasm manifests special physico-chemical properties; but it may be difficult to decide whether these peculiar characters are the effect of the previous differentiation of secreting organs in the midst of the protoplasm, or of an alteration impressed secondarily on the living substance by the substance which has become foreign to it; it has not always been possible to discern the modified protoplasm from the product of secretion.

The discussions raging around the two fashionable words of the day: *chondrione*, *metachromatic corpuscles*, reflect the difficulties of the subject. * * * We will confine ourselves to examining, in so far as they concern the Fungi: A, the theory of the chondrione; B, the metachromatic and other products of secretion.

A.—*The theory of the Chondrione.*

Mycologists have not escaped the infatuation which saluted the discovery of the mitochondria. Though the latest comers in the lists they have proved by the quantity of notes accumulated since the first communication of M. Guilliermond[45] that they were ready at the first signal to undertake a minute exploration of the cellular structure of the Fungi, wherein the knowledge of the nucleus had furnished brilliant results * * *

Great theories based on small facts must be regarded as hypotheses until they have met the test of time. Time has already verified the interpretation of Benda, in whose eyes the mitochoridris, first observed in the seminal cells of animals, were the immutable tabernacle of heredity. The chondrione, under its various aspects, chondrisomes, nitochondria, chondriocontia, not to mention the plasts and other connected organs, is more unstable than any portion of the cell. Hence we may hesitate to accept M. Guilliermond's[46] view that it is a new element of the cell "whose presence is as constant and whose rôle as essential as that of the nucleus."

The chondrione is presented to us as independent of the nucleus and of the cytoplasm. Many authors behold a dependence on the nucleus, Tischler, Von Derschau, connect it with the chromidia, chromatic particles escaped from the nucleus, transitorily or definitely freed from its influence. Guilliermond[47] has indeed observed chondriocontia drawn along passively by the displacements of the nuclear elements in the course of the mitosis. Bezssonoff[48] sees the condriocontia of the ascus of the Erysiphaceae accompanying the chromosomes. Many, however, hold to the view of Duesberg and Hovet[49] that the chondrione takes no direct part in the nuclear division.

Outside the nucleus we find basophilous grains of unknown origin. Pénau points out in the *Endomyces albicans*[50] a basophilous network, in the *Sporotrichum Beumanni*[51] conglomerates of basophilous substance independent at once of the nucleus and of the cytoplasm. Outside these the same cells contain metachromatic corpuscles, generally regarded as products of the chondrione. Guillermond does not hesitate to annex to the chondrione a portion of the basophilous grains.

[TO BE CONTINUED]

[51] *C. R. Soc. Biol.*, vol. LXXIII, 1912.

[34] *Annals Botany*, vol. XXV, 1911.
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plurinucleat ascogone of the *Ascophanus carneus*. Carruthers[34] perceives them only in the hypothecium of the *Helvella crispa*. Often, as we know, there is only one dicaryon in the crotch which bears the ascus.

The Basidiomycetes, like the other Eumicetes, have a dicaryophase. External vestiges of the differentiation of the sexes are rare and disputed in this superior group; it is all the more instructive to determine the relations of position between the first conjugated nuclei and the supposed spermatia of the Coprinae. This is the principal point of interest in the memoir of Kniep.[35] The basidiospore of the *Coprinus agithemerus* germinates in a polrinuclear vesicle; the filaments which proceed therefrom have cells whose single nucleus is haploid; from it there separate rods, which are probably vestiges of gametes which have lost their function and at present constitute haplobasidia. Sometimes the whole mycelium retains the simple character, the conjugated nuclei appearing in the first rudiment of the receptacle. More often the conjugated nuclei reveal themselves in the course of the mycelian development; when the mycelian dicaryophase is prolonged it is complicated by the formation of rings uniting the consecutive binuclear cells. Kniep[35] has come back to the cytology of these enigmatic organs which are so widely found among the *Hymenomycetes*. The ring cells have two conjugated nuclei; the ring appears at the periphery of the terminal cell in the form of an excrescence situated at an equal distance from the two nuclei; the excrescence curves inward toward the preceding cell; each nucleus undergoes a mitosis in such a way that there are two apical nuclei and two basal nuclei; one of the apical nuclei serves in the ring as an isolated partition; a transverse partition separates at the same time the two basal nuclei; the ring proceeds to open underneath this partition, and the migrating nucleus penetrates into the new subterminal cell. The nuclei of the new couple have a relationship therefore which is a degree more distant than the conjugated nuclei from which they proceed.

The author compares the formation of the rings of the Basidiomycetes with the formation of the hooks in the Ascomycetes. We invite attention also to their resemblance to the biped support of the sporiferous sacs of the *Dipodascus*. The example of the Hymenomycetes furnishes further information: the formation of rings is independent of the appearance of conjugated nuclei; by the exchange of nuclei it achieves a supplementary correction of the lack of exogamy. To return to the Coprin, it coincides, like the formation of conjugated nuclei, with the period when the supermatia, probable vestiges of the suppressed exogamy, exhibit themselves.

In the *Hypochnis terrestris*, a new species studied by Kniep, in the *Cyathus Olla* studied by Malinowsky[37] as well as in the immense majority of the Basidiomycetes, the first conjugated nuclei appear in the basidiospore; the haplophase, therefore, comprises at most the two dimensions of the nucleus of conjugation of the basidium.

The shortening of what it is the custom to call the gametophyte scarcely seems likely to exceed this limit. However, in an Agaric of Tonkin which Patouillard[38] has been led to inscribe among the *Pasthyrella* the gills are laden with bulbils which the nuclear evolution studied by Moreau[39] leads us to regard as encysted basidia. The two nuclei, distinct at the beginning, become fused; the diploid nucleus divides into two parts by typical mitosis, restoring the simple type; a second mitosis is followed by the degeneration of two of the four nuclei, which brings the cells back to the binuclear type.

C.—*Caryogamy and Caryomixia foreign to Sexuality.*

Outside the phenomena connected with sexuality, plurinuclear cells are encountered or, if we restrict the idea of the cell to the presence of a single nucleus, polyenergidian elements, not only among the Phycomycetes, but also in various Eumycetes. We have cited examples of them among the *Pyronema*, *Polystigma*, *Protomyces*, etc. The four ascospores of *Podospora anserina*, according to Wolff[40], each enclose two nuclei, while its congeners possess 8 or 16 uninuclear spores. This case differs essentially from that of the basidiospores with two nuclei, since the membrane of the ascospore has united two nuclei previously separated while the basidiospore was at first provided with a single nucleus. Moreover, the ascospore germinates in haploid filaments, while the basidiospore inaugurates the stage of conjugated nuclei which will come to an end in the new basidia. The conjugated nuclei are distinguished not only by their coming together and their simultaneous division, but also and especially by the period of ontogeny which characterizes them.

The uniclear fusion, the caryomixia (caryogamy of Moreau, etc.), is independent of sexuality when it does not prepare the return of the diplophase to the haplophase. Moreau[41] has pointed out the vegetative fusions of the nuclei in the columella of *Zygorhynchus Dangeardi*. In his researches upon *Ascophanus carneus* Ramlow[42] determined that one portion alone of the nuclei of the ascogone emigrates by pairs into the ascogenous filaments; the others swell up; often several flow together and form large vesicles with two or three nucleoles; these are the supposed zygotes of Miss Fraser. In fact they degenerate on the spot.

Miss Keene[43] describes phenomena of the same kind in the Mucorineae. In the zygospore of *Sporodinia grandis*, the nuclei which have had no part in the regular formation of zygotes are digested by the confluent Elaeoplasts, formerly taken by Léger for embryogenic spheres; by Dangeard for chromatic corpuscles; by Lendner for large copulative nuclei. In the same way, according to Schürloff,[44] there are in the asparagus stalk giant nuclei resulting from the nuclear fusion which serve as materials, with the cells which contain them for the construction of vascular fascicles.

We find, therefore, throughout the whole extent of the vegetable kingdom associations and fusions of nuclei, caryogamies and caryomixias quite distinct from the similar images which mark the stages of sexual evolution.

III. CYTOLOGIC CHARACTERS DEPENDING UPON SECRETION

Living cells contain substances separated from the protoplasm by the secretive function. Among the Fungi it is rare for the intra-cellular secreting organs to be as clearly defined as the plasts or leucites of green plants. On contact with solid or liquid inclusions protoplasm manifests special physico-chemical properties; but it may be difficult to decide whether these peculiar characters are the effect of the previous differentiation of secreting organs in the midst of the protoplasm, or of an alteration impressed secondarily on the living substance by the substance which has become foreign to it; it has not always been possible to discern the modified protoplasm from the product of secretion.

The discussions raging around the two fashionable words of the day: *chondrione*, *metachromatic corpuscles*, reflect the difficulties of the subject. * * * We will confine ourselves to examining, in so far as they concern the Fungi: A, the theory of the chondrione; B, the metachromatic and other products of secretion.

A.—*The theory of the Chondrione.*

Mycologists have not escaped the infatuation which saluted the discovery of the mitochondria. Though the latest comers in the lists they have proved by the quantity of notes accumulated since the first communication of M. Guilliermond[45] that they were ready at the first signal to undertake a minute exploration of the cellular structure of the Fungi, wherein the knowledge of the nucleus had furnished brilliant results * * *

Great theories based on small facts must be regarded as hypotheses until they have met the test of time. Time has already verified the interpretation of Benda, in whose eyes the mitochoridris, first observed in the seminal cells of animals, were the immutable tabernacle of heredity. The chondrione, under its various aspects, chondrisomes, nitochondria, chondriocontia, not to mention the plasts and other connected organs, is more unstable than any portion of the cell. Hence we may hesitate to accept M. Guilliermond's[46] view that it is a new element of the cell "whose presence is as constant and whose rôle as essential as that of the nucleus."

The chondrione is presented to us as independent of the nucleus and of the cytoplasm. Many authors behold a dependence on the nucleus, Tischler, Von Derschau, connect it with the chromidia, chromatic particles escaped from the nucleus, transitorily or definitely freed from its influence. Guilliermond[47] has indeed observed chondriocontia drawn along passively by the displacements of the nuclear elements in the course of the mitosis. Bezssonoff[48] sees the condriocontia of the asci of the Erysiphaceae accompanying the chromosomes. Many, however, hold to the view of Duesberg and Hoven[49] that the chondrione takes no direct part in the nuclear division.

Outside the nucleus we find basophilous grains of unknown origin. Pénau points out in the *Endomyces albicans*[50] a basophilous network, in the *Sporotrichum Beumanni*[51] conglomerates of basophilous substance independent at once of the nucleus and of the cytoplasm. Outside these the same cells contain metachromatic corpuscles, generally regarded as products of the chondrione. Guillermond does not hesitate to annex to the chondrione a portion of the basophilous grains.

[TO BE CONTINUED]

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